Resolving the growth challenges of high technology new ventures: An absorptive capacity perspective

Presented by

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Submitted in fulfilment on the requirements for the Degree of

Doctor of Philosophy

UNIVERSITY
of
GLASGOW

Business School
College of Social Sciences
University of Glasgow

December 2011

Abstract

This thesis examines how high technology new ventures (HTNVs) in the life science industry in Scotland leverage external knowledge to resolve challenges that they face at critical events to enable the firm to grow. The theoretical approach is holistic, drawing on the fields of entrepreneurship, innovation and internationalisation, which are all key drivers of the growth of HTNVs. Reviews of this diverse literature point to the key role of knowledge for the growth of these firms, however, little is known about the processes and routines that enable them to leverage knowledge. Therefore, the construct of absorptive capacity (ACAP) is an appropriate lens to investigate how HTNVs resolve growth challenges by leveraging external knowledge. As this is a complex issue, this exploratory study takes a holistic view, drawing on the interpretivist paradigm, and utilises in-depth case studies to examine key challenges that firms face at critical events, and the knowledge leverage processes associated with these events.

A key finding is that HTNVs experiencing rapid growth have to address a number of growth challenges simultaneously in relation to the three key drivers of growth. Therefore, the knowledge processes that support this activity transcend functional boundaries and are interlinked with and interdependent on these simultaneous business processes. With limited internal resources, the demand of these firms for external knowledge to resolve these challenges is acute. The six types of knowledge that firms were found to require are: market, technical, managerial, regulatory, internationalisation and relational knowledge. The firm's ability to combine different types of knowledge from outwith the firm and from within the firm's knowledge stocks to find solutions for the challenges they face is important for their growth.

The major contribution of this thesis is that the pace of the leverage of knowledge at critical events is maximised when HTNVs have multiple enablers of ACAP in place. This has emerged from combining other findings on key enablers and temporality of ACAP. A new process model of ACAP is proposed, which highlights the connection between the individual- and firm-level ACAP, and emphasises the importance of effective communication within the firm and the effective management of the firm's knowledge stocks to maximise the firm's ability to exploit the knowledge it acquires. The model also highlights the importance of social capital to the ACAP process, in particular to the timely acquisition and assimilation of knowledge. This process model significantly enhances the understanding of how knowledge is leveraged through the ACAP process.

There are important implications in these findings, amongst which there is evidence that social capital provides the firm with timely access to the knowledge, in particular the links of board members. In dynamic industry environments where there are constant technological advances and market opportunities are short-lived, the ability to assimilate and respond to opportunities and threats quickly is crucial to the firm's competitive advantage. For the management of HTNVs, understanding how to optimise the use of their Boards of Directors, including venture capital representatives, in order to leverage their experience and connections, can significantly enhance the firm's competitive advantage. Furthermore, exploiting the firm's social capital in order to access and assimilate knowledge more effectively could have a significant impact on the growth of the firm. At policy level, it is imperative that small firms are encouraged to invest in the enablers of ACAP, to develop appropriate connections across the value chain that can assist their growth and, in particular, to ensure that they appoint to their Board Non-Executive Directors who are appropriate to the key challenges they are facing.

Acknowledgements

There are many people that I must thank for their help on my PhD journey. This journey would not have been possible without them.

First and foremost, I am especially thankful to my supervisor Professor Marian Jones. It has been a real honour and privilege to work with her. Her invaluable input, patience and support has kept me motivated and guided me to the end. I also thank my secondary supervisor Dr Moira Fischbacher-Smith who also helped to guide me.

Many thanks to all the professors who helped me during my time at the University of Glasgow, especially the members of the research community at the Centre for Internationalisation and Enterprise Research (CIER) who provided helpful advice through the seminars and workshops of the Doctoral Programme. A special thanks to Anne McCusker who always went out of her way to provide support.

Thanks also to Professor James Taggart of the University of Glasgow (now retired) for persuading me to start this research on completion of my MBA, which set me on this incredible learning journey.

Another group I really need to thank is my fellow PhD students on the Doctoral Programme. You are a wonderful group and I hope to remain life-long friends with all of you. Thanks to Lucrezia Casulli, Nathaniel Massa, Jon Carrick, Karl Warner, Roland Kuepfer, Ewe Hermann, and George Vlachos who have shared this research journey with me.

This PhD would not have been possible without the participation of nine high technology new ventures. I am indebted to the management teams of the firms that gave up their precious time to participate in this research. For reasons of confidentiality, they cannot be named.

Without the constant support and understanding of my family and friends, this thesis would not have been possible. A huge thanks to my husband Robin and children Maxwell (5) and Fraser (2) for their indulgence of my countless days of absence from family activities throughout this lengthy period of part-time research. I dedicate this thesis to you.

Author's Declaration

The attached material is submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy at the University of Glasgow, and accords with the University Regulations on plagiarism as detailed in the Programme Handbook and University Calendar.

I declare that, except where explicit reference is made to the contribution of others, this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Signature :

Gillian Cay
December 2011

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Chapter 1

Introduction

This introductory chapter sets the scene for the research presented in the rest of the thesis. The chapter begins with an introduction to the research problem which drives the research presented in this thesis, namely the leverage of knowledge by high technology new ventures (HTNVs) to resolve growth challenges at critical events. The next section provides a background for this research, and outlines why the knowledge processes of HTNVs is a topic that deserves further exploration. It explains that due to lack of holistic approaches to the growth and development of HTNVs, this research draws on diverse aspects of management literature, all of which point to the importance of knowledge and the ability to exploit it as being important for firm growth. Drawing on Jones (1999) and Onetti et al. (2010), this thesis takes a holistic approach to the exploration of the knowledge processes associated with key integrated entrepreneurial processes of entrepreneurship, innovation and internationalisation. The chapter then moves on to outline the research objectives, the relevance of absorptive capacity (Cohen & Levinthal, 1990) as a research framework, and the research approach and methodology. The personal motivation for this project is then outlined. The chapter goes on to discuss the context in which this study was conducted; that is, the life science industry in Scotland. The dynamic and truly global nature of the industry means that HTNVs have complex knowledge requirements to enable their growth, making it an ideal setting for this study. The chapter concludes with an outline of the structure of the thesis and the content of each chapter.

1.1 Introduction

One key question drives this research, and it can be summed up as follows:
"How do HTNVs leverage external knowledge to enable the growth of the firm?"
This question arose in 2003 when I was managing a networking organisation for life science firms aimed at building connections and sharing knowledge. It soon became clear that these firms have a high and complex demand for external knowledge, and that the speed of response to challenges they face has an impact on their growth and development. A review of diverse fields of literature highlighted that there is still a lack of understanding of how knowledge is leveraged by HTNVs to enable their growth. These firms are particularly interesting as they are small, inexperienced, constrained in resources, with all

the liabilities of smallness and newness, and yet their demand for knowledge is acute. Therefore, in order to grow, they must effectively acquire external knowledge and exploit it successfully to resolve the challenges they face and move to the next phase of growth (Phelps et al., 2007).

This doctoral research study therefore took an inductive approach involving multiple case studies of HTNVs, examining the challenges that these firms faced at critical events and how they leveraged knowledge to resolve these challenges. Absorptive capacity (Cohen & Levinthal, 1990), a concept which has been redefined by Zahra and George (2002b) as a dynamic capability that enables the use of external knowledge, is utilised as the research lens for this study. The specific context of this study is the small HTNV within the life science industry in Scotland, balancing the paradox of long and complex development lead times, and the requirement for fast market access in a global industry to capitalise on significant investment in R&D.

This thesis aims to contribute to the theory of small firm growth and ACAP in a number of ways. Firstly, by taking a holistic approach to key integrated entrepreneurial processes, it draws insights from the fields of entrepreneurship, innovation and internationalisation. In taking this approach, it provides a holistic view of the knowledge requirements of HTNVs at critical events, and the key mechanisms that enable these firms to address their challenges through the leverage of knowledge. Secondly, this study also highlights the importance of understanding the dynamics of the complex global value chain for HTNVs and the key role of social capital in building relationships across the value chain to access tacit knowledge. Thirdly, by utilising ACAP as a research framework, this thesis also aims to contribute to the development of ACAP theory through an examination of the inner processes of ACAP and to provide additional understanding in the context of HTNVs. Furthermore, insights into the challenges faced by HTNVs at critical events and their complex knowledge requirements, to enable them to resolve challenges and enable growth, have particular relevance to managers of HTNVs and to the policy makers who develop interventions to support these firms.

1.2 Background issues and importance of the topic

This thesis explores the multiple challenges facing small HTNVs, with respect to their development and growth, and investigates how they leverage knowledge to resolve these challenges. This section presents a background to this research, highlighting why this is a topic that merits further exploration.

1.2.1 Growth of high technology new ventures (HTNVs)

HTNVs have been identified as being different from other SMEs in that they are created with the specific purpose of maximising the return from the technology upon which they were founded. HTNVs are important because they are seen by many governments as having a pivotal role to play in the regeneration and growth of national economies (Audretsch, 1995). The Annual Report on EU SMEs 2010/2011 states that there were 20.8 million SMEs in Europe in 2010, accounting for 99.8% of all enterprises. An analysis by the Observatory of European SMEs (2002:18), which has not been repeated more recently, showed that 746,000 European SMEs were active in high-tech industries in 2000, employing approximately 5 million people, with the average firm size well above the respective ratio for non-high-tech SMEs (7 versus 4 employees). However, the failure rate of many of these firms is high and of those that do succeed, very few become significant employers (e.g., Birley, 1987). The high-technology sector is perceived to experience the extreme manifestations of the pressures that accompany growth, and the need to adapt and change to a rapidly-changing environment. Dynamic high-technology sectors present significant opportunities, but also run high risks. HTNVs are of particular interest in this study because they are small, inexperienced, constrained in resources, with all the liabilities of newness, yet their demand for knowledge is acute and therefore in order to grow, they must effectively acquire external knowledge and exploit it successfully to overcome the challenges they face and move to the next phase of growth (Kazanjian, 1988; Vohora et al., 2004; Bessant et al., 2005; Phelps et al., 2007). These factors, together with the fact that there has been so much government support for these ventures, have made HTNVs a particularly attractive phenomenon of study for academic scholars. The challenge for policy makers is how to create an environment of support that facilitates growth, and as the firms grow, ensure that they maintain the ability to be flexible and

respond to new opportunities and challenges.

1.2.2 HTNVs and the drivers of growth

For HTNVs, innovation is seen as a key driver of growth as the firm exploits opportunities by developing new products and processes based on technological innovation (e.g., Shane & Venkataraman, 2000). Many HTNVs are niche players in global value chains (e.g., Hine & Kapeleris, 2006) and are therefore international in their outlook from inception. HTNVs are typically members of multiple partnerships and utilise alliances up and down the value chain to realise their objectives. In order to maximise the returns for their investors, HTNVs that develop new technological platforms are typically simultaneously involved in developing commercial applications of their technology, building links with potential customers for these applications in international markets, while establishing the growing firm (Onetti et al., 2010). Therefore, for HTNVs, innovation, internationalisation and entrepreneurship should be considered from a holistic perspective, as they are integral to the overall growth of the firm (Jones, 1999). As a result of limited resources, there can be tensions among these processes (Saemundsson, 2005), particularly in the life science industry, where there are high development costs and long development lead times, but a relatively short window of opportunity to make a commercial return. HTNVs have to overcome significant constraints in relation to smallness, newness and lack of resources, in order to manage the requirements of key integrated entrepreneurial processes.

1.2.3 Growth of HTNVs and the role of knowledge

The dynamic and knowledge-intensive nature of high-technology industries requires the strategic application of knowledge resources. Due to a lack of holistic approaches to the growth and development of HTNVs in the existing literature, this study has drawn from a number of fields of study, reviewing the role of knowledge and knowledge processes in the growth of these firms.

The review of several diverse aspects of management literature in Chapter 2 points to the important role of knowledge for the growth of the firm. It highlights that knowledge plays a key role in all other factors that impact growth and therefore cannot be seen independently.

A review of theories of firm growth highlights not only that knowledge is a significant resource for the firm, from the resource-based view of the firm (RBV) (e.g., Barney, 1991) and the knowledge-based view (KBV) (e.g., Grant, 1996a; Spender, 1996a) of the firm, but also the importance of having the capability to exploit that knowledge. This is highlighted by Penrose's (1959) 'The Theory of the Growth of the Firm' and the dynamic capabilities view (e.g., Eisenhardt & Martin 2000; Pisano, 2000). The ability of managers to recognise relevant knowledge, interpret and disseminate it to relevant staff throughout the organisation, and to combine that knowledge with other knowledge from within and outwith the firm, impacts on the ability of the firm to leverage the knowledge to enable the firm to grow.

A review of the literature on the key drivers of growth for HTNVs also highlights that knowledge plays an important role in innovation, internationalisation, and entrepreneurship. It is also noted that the knowledge required is likely to be predominantly outwith the firm's boundaries (e.g., Fernhaber & McDougall-Covin, 2009). The literature relating to growth across many diverse fields of management all highlight the importance of knowledge acquisition and assimilation to the performance and growth and points to absorptive capacity (Cohen & Levinthal, 1989; 1990) as being an important capability which differentiates the firm and enhances performance.

1.3 Research objectives, framework and approach

This research takes a holistic approach to exploring how HTNVs leverage knowledge to resolve challenges at critical events, encompassing the key integrated entrepreneurial processes of entrepreneurship, innovation and internationalisation.

1.3.1 The research objectives

The principle aim of this research is to develop a deeper understanding of how HTNVs leverage external knowledge at critical events to enable their growth. The overall purpose of this research is exploratory with a view to making a contribution to theory (in the fields of small firm growth and absorptive capacity), and practice (providing insights into management and policy makers). The research objectives which are stated explicitly in

Chapter 4 are concerned with the exploration of the knowledge processes that leverage external knowledge, and the impact on the growth and development of the firm.

The primary research question for this thesis is, in the context of the life science industry in Scotland:

- *How do HTNVs leverage knowledge at identified critical events to resolve growth challenges?*
- *What are the temporal aspects of knowledge leverage by HTNVs at critical events?*

The objectives are broken down in to research questions which determine the methodologies employed for data collection, analysis and presentation. Secondary research questions are outlined in Chapter 4.

1.3.2 Absorptive capacity as a research framework

Absorptive capacity (ACAP) represents a concept that links knowledge acquisition and assimilation with the exploitation of that knowledge whereby firms develop new capabilities (Cohen and Levinthal, 1990). Having been redefined by Zahra & George (2002b) as a dynamic capability that enables the use of external knowledge, ACAP is an appropriate research framework through which to explore the leverage of external knowledge by HTNVs.

Since Cohen and Levinthal (1989; 1990) published their seminal work on absorptive capacity (ACAP), the importance of ACAP has been noted across the fields of strategic management (Lane & Lubatkin, 1998; Nahapiet & Ghoshal, 1998), technology management (Schilling, 1998), international business (Kedia & Bhagat, 1988), marketing (Matthysen et al., 2005), organisational economics (Glass & Saggi 1998), and the resource-based view of the firm (Barney, 1991). The development of ACAP theory is reviewed in Chapter 3. A major contribution to its development is the reconceptualisation of ACAP by Zahra and George (2002b:186) as a dynamic capability, which defines ACAP as "a set of organizational routines and processes by which firms *acquire, assimilate, transform, and exploit* knowledge to produce a dynamic organizational capability", and suggests that these four dimensions exist as two subsets of 'potential' (PACAP) and 'realized' absorptive

capacities (RACAP). However, 80% of the literature cites the construct in a ritual manner with little or no discussion (Lane et al., 2006). Reviewing the literature relating to measures of ACAP has highlighted that all quantitative research in the field, including Cohen and Levinthal (1990), has used proxy measures. There is no standard measure, although the majority of studies use measures of R&D capability and R&D intensity, which also vary greatly. This is not a reliable methodological approach for a poorly-understood construct. The focus of most of the ACAP literature on R&D functions within the firm points to another key gap in the literature. Literature on the commercialisation of innovation acknowledges the need for market knowledge successfully to exploit innovation, but this has not been explored in a holistic way by ACAP. There is also a disconnect, in that down-stream value chain researchers in the fields of marketing tend to discuss the acquisition and assimilation of knowledge as the construct of 'market orientation' with no cross-reference to the developing field of ACAP. Lane et al. (2006) in their critical review of peer-reviewed academic papers that focus on ACAP from 1991 to 2002, suggest that the ACAP construct has become 'reified', and Easterby-Smith et al. (2008) calls for researchers to further develop process models of ACAP. The review of the literature to date suggests that for this research to make a valuable contribution, it should go 'back to basics' and explore the inner processes of ACAP.

Using the research lens of the ACAP process (adapted from Zahra & George, 2002b - see figure 4.5), this exploratory study takes a process approach to examine the routines for the acquisition and assimilation of external knowledge, and how external knowledge is transformed over time through the ACAP process to enable firm growth. This holistic process approach to the leverage of knowledge by HTNV is very much at the 'heart' of the ACAP construct and aims to add significantly to its development.

1.3.3 Research approach

This study adopts an interpretivist paradigm, which focuses on deep meanings and aims to understand what is happening in the totality of each situation. An interpretivist paradigm is suitable for this research as it recognises that business situations are complex, and unique as a function of a particular set of circumstances and individuals (Saunders et al., 2007). Recognising that organisational processes are embedded in their context (Pettigrew, 1992),

the approach for this research is inductive and acknowledges that the leverage of knowledge is context-specific.

A qualitative, multiple case study methodology based on interviews with CEOs and senior management is used to explore the leverage of external knowledge in 7 HTNVs within the life science industry in Scotland. A holistic approach is considered appropriate for an exploratory study of a construct such as ACAP, which is not well defined. A variety of methods were used to analyse this complex process. Case studies were analysed using both within-case and cross-case methods, as recommended by Miles and Huberman (1994). The methodology is outlined in detail in Chapter 5.

1.4 The motivation for this research project

In order to understand the researcher's motivation, it is important to have some information on her background. Training initially as a life scientist, I subsequently had 17 years of experience as a marketing professional, of which 14 were in the life science industry. When I began this part-time research, I had recently started a new role as manager of a networking organisation for life science companies in Scotland, with the objective of assisting companies to build connections and to share knowledge. Therefore, I was motivated to develop a deeper understanding of the challenges faced by these firms, what sort of knowledge they required to resolve their challenges, how networks could help them source that knowledge, and how companies internalised that knowledge to enable them to exploit it to their advantage. Meeting many small life science companies in this role made me question how small HTNVs make use of knowledge, why are some able to absorb and exploit knowledge efficiently and develop new capabilities quickly, and why some companies, although exposed to the same knowledge, do not capitalise on it. I decided to complement this anecdotal evidence from discussions with client companies with an academic research project to understand how HTNVs in the life science industry leverage external knowledge to resolve the challenges they face. My current role in Scotland's economic development agency, Scottish Enterprise, is focussed on supporting the growth of the life science sector in Scotland. Therefore, an understanding of how HTNVs can leverage external knowledge to facilitate their growth is of benefit to policy makers developing appropriate interventions to support economic growth.

1.5 Research setting

The research setting for this study is the life science industry in Scotland. The life science industry has been identified as a key sector with the potential to fuel the future growth of the Scottish economy (Scottish Government, 2010). Scotland has a world-renowned knowledge base in the life sciences and has had reasonable success in creating new life science ventures. In fact, a recent UK life science start-up report by Mobius Life Sciences (2010) states that Scotland had the highest rate of life science start-ups per capita in the UK between 2005 and 2009. However, historically, many of these small HTNVs fail and very few grow to become significant employers and make a real contribution to the economy. Therefore, exploration of how HTNVs in the life science industry can leverage knowledge to facilitate their growth is of paramount importance to the economy, in addition to contributing to the academic knowledge in the field of small firm growth.

The next two sections explore the global nature of the life science industry and the importance of external knowledge for the industry, highlighting why this industry is an ideal setting in which to explore the routines for the leverage of external knowledge by HTNVs. HTNVs in the life science industry are particularly dependent on external knowledge for innovation and internationalisation. Since externally-sourced knowledge is so important for the growth of life science firms, it is important to consider how firms can improve their ability to access and utilise this knowledge.

1.5.1 Life sciences as a global industry

The life science industry, like other knowledge-intensive industries is made up of complex global value chains. As a result, HTNVs operating in the life science industry tend to be international from their inception and can be described as international new ventures (INVs) (Oviatt & McDougall, 1995). The key characteristics of this global industry are described below:

- Firstly, the homogeneity of life science products and services, which provide identical functionality throughout all geographical markets, contributes to a life science HTNV's ability to service multiple markets. Biochemical processes are

largely the same around the world, so life science HTNVs can penetrate global markets (Gassman & Kuepp, 2007). As products require little modification, the marginal cost of internationalisation is kept to a minimum and there is little or no psychic distance from internationalising, even in culturally distant markets (Gassmann & Kuepp, 2007:356).

- Due to the global connectedness of the life science industry, embeddedness in global communities and networks is vital in order to build relationships and access tacit knowledge (Gassmann & Kuepp, 2007). This echoes the work of Coviello (2006), which provides evidence that INVs benefit from competitive capability and information advantages generated by their networks. In a globally connected scientific community, the leaders in each particular scientific field understand the language that has evolved around that science.

- Life science HTNVs vary in their degree of internationalisation and the modes of entry that they use. Many internationally active SMES do not export. By the nature of international value chains such as those prevalent in the life science industry, SMEs can serve world markets by virtue of the intellectual property they have developed (Gassman & Kuepp, 2007). Many specialist service companies in the life science sector, such as contract research organisations, deliver results of experimental testing electronically. This fits with the view of Miller and Shamsie (1996), that in the dynamic environments in which INVs operate, knowledge-based resources contribute more to the firm's performance than do property-based resources.

- HTNVs in the life science industry fulfil a function as specialised service providers in international value chains (Gassmann & Kuepp, 2007). For example, the output of a specialist drug discovery company is intellectual property, which is developed into a product by a pharmaceutical company further down the value chain. This is consistent with the view of Jones (1999) that internationalisation for HTNVs is not contingent on the INV marketing its own products. While HTNVs are developing their technology, they must make the appropriate international connections across the value chain in order to be able to build relationships with potential development

partners and customers. HTNVs also source services from and collaborate with other international suppliers.

- The life science industry is highly regulated by regulatory authorities, so international sales are restricted by national standards and approval processes (Gassmann & Kuepp, 2007).

There are significant challenges for small firms with limited resources in successfully entering this complex global industry and servicing clients in multiple geographical markets. These characteristics of the global life science industry suggest that a holistic approach to the challenges faced by HTNVs is appropriate, encompassing entrepreneurship, innovation and internationalisation.

1.5.2 The life science industry and the role of knowledge

The importance of knowledge to the life science industry has been well documented. Pisano (2006:12) describes the industry as "dancing on the edge of knowledge", arguing that "in a highly turbulent rapidly evolving context like life sciences, organizational learning matters" (:13). Pisano describes the toolkit of drug R&D as becoming larger, more complex and vastly more heterogeneous in the last 30 years. Modern drug R&D comprises molecular biology, cell biology, genetics, bioinformatics, computational chemistry, protein chemistry, combinatorial chemistry, genetic engineering, high throughput screening and many other fields. These tools are opening up many new opportunities, but integration of appropriate knowledge and skills across diverse fields is a major challenge for life science firms trying to develop a new product.

The development of the firm's ability to access external knowledge sources is not limited to activities that take place within the firm (Fabrizio, 2009). Cockburn and Henderson (1998) and Zucker et al. (1994, 1998) have emphasised "connectedness" to external knowledge sources, and in particular scientists, as providing benefits in terms of accessing and sourcing external knowledge. It is clear that collaborations between firms and external researchers aid in identifying and incorporating external science (Fabrizio, 2009). There has been considerable research addressing the issue of learning and knowledge transfer in

firm-to-firm strategic alliances in the life science industry (e.g., Mowery et al., 1996; Stuart, 2000, Grant & Baden-Fuller, 2004).

Recent work on the "open innovation" paradigm draws attention to the fact that firms benefit from an active awareness and focus on external research and innovation (Chesbrough, 2003: Laursen & Salter, 2006). Firms in the 'drugs and medical products' industry report that their innovations draw heavily on academic research and that new products and processes would have been delayed without access to this research (Mansfield, 1991, 1998; Collins & Wyatt, 1998). Therefore, this suggests that firms in this industry must develop mechanisms by which different organisations (e.g., universities, hospitals, start-ups, biotechnology firms, large pharmaceutical firms) can interact effectively to enable multidisciplinary problem solving. This is consistent with Cockburn and Henderson's argument that "a firm that operates under a particularly insular research culture will have difficulty keeping up with recent scientific developments, while a firm that maintains connections with a large research community will enjoy superior access to the knowledge within that community" (Cockburn & Henderson, 1998). Collaborations not only identify relevant scientific research, which may or may not be in the public domain, it also provides the firm with access to the tacit knowledge linked to published research results. Due to the tacit nature of knowledge, reading the published or codified research results may not be enough for a firm to be able to utilise or exploit that knowledge in the absence of the related tacit knowledge that is uncodified (Dasgupta & David, 1994). Von Hippel (1994) states research-related knowledge often resides with the researcher and is very "sticky" and difficult to transfer.

Given the high knowledge demands of this complex global industry, it is an appropriate research setting for this study.

1.6 Structure of thesis

The main theme running through this thesis is the leverage of knowledge by HTNVs to resolve growth challenges at identified critical events which have impacted on the growth and development of the firm. This is examined through the lens of the absorptive capacity process, and within the research setting of the life science industry in Scotland.

The thesis contains eight chapters inter-related as illustrated in Figure 1.1, and is structured as follows:

Chapter 1 has introduced the research problem, the background to the topic, the relevant literature relating to the key drivers of growth for HTNVs, the research setting, the research objectives and framework, the research approach and the structure of this thesis.

Chapter 2 presents a review of literature on the growth of HTNVs. In recognition that young technology based firms are simultaneously advancing a number of processes (Jones, 1999; Ovetti et al., 2010), this chapter takes a holistic approach, drawing on the key theories of firm growth and the fields of entrepreneurship, innovation and internationalisation, which all suggest that knowledge and knowledge processes are of key importance to the growth of the firm (Grant, 1996b). The chapter highlights insights from recent entrepreneurship literature on the resolution of challenges at critical events to enable the firm to develop and grow (Phelps et al., 2007). Furthermore, due to the dynamic nature of knowledge-intensive global industries, the speed at which solutions can be found to challenges at critical events impacts upon growth outcomes (Kazanjian, 1988). HTNVs have a high demand for knowledge and due to their lack of internal resources, must be able to effectively absorb external knowledge (Zahra, 1996) and exploit it successfully to enable their growth.

Chapter 3 presents a review of the absorptive capacity (ACAP) literature to date. ACAP represents a concept that links knowledge acquisition and assimilation with the exploitation of that knowledge whereby firms develop new capabilities (Cohen and Levinthal, 1990). This chapter concentrates on the development of the ACAP theory, outlines the dimensions of ACAP (Zahra & George, 2002b) and reviews existing literature on enablers of ACAP. An examination of ACAP's role in entrepreneurship, innovation and internationalisation reinforces the importance of acquisition and application of external knowledge to address challenges faced by the firm. This chapter also reviews the relationship between ACAP and organizational learning, highlighting ACAP's role in problem resolution (Cohen & Levinthal, 1994; Kim, 1998), which makes it an ideal framework to explore the research question.

Chapter 4 is the most important chapter of the thesis. In this chapter the conceptual approach to the research problem is developed, the underlying theory identified and the constructs explained. Drawing on the literature review in Chapter 2, this chapter explains the holistic approach to exploring the key integrated entrepreneurial processes of HTNVs and their requirement to leverage external knowledge at critical events. The chapter presents explicit statements of the aims and objectives of the research, and outlines the key questions to be addressed by the research. The research lens for this study is based on Zahra and George's (2002b) dimensions of ACAP and identifies the secondary research questions used to analyse the data.

Chapter 5 presents the research methodology and approach adopted for this research. The chapter picks up the conceptual development discussed in the previous chapter and outlines the process to be followed in the practical operationalisation of the research. This research adopts a subjective approach base on an interpretivist paradigm using a process of induction to derive deep insights (Eisenhardt, 1989) into the leverage of knowledge by HTNVs at critical events to resolve growth challenges. The approach is particularly relevant to this research, as organisational knowledge processes are embedded in context (Pettigrew, 1992, 1997). The rationale for the selection of the case study method, embedded unit of analysis (Yin, 2003) and selection of sample of HTNVs, is discussed, along with measures taken to ensure rigour, following Yin's (2003) recommendations. The data collection methodology includes a discussion of the use of in-depth interviews as the primary data collection tool, and the triangulation of data. The chapter goes on to describe the analysis strategies utilised, beginning with within-case analysis which involved three steps: narrative sequence analysis, visual mapping and analytical abstraction (Miles & Huberman, 1994). In keeping with the ACAP research lens, the meta matrices created for the cross-case analysis (Miles & Huberman, 1994) focuses on the processes occurring at the dimensions of ACAP: acquisition, assimilation, transformation and exploitation. The themes that emerge from the ACAP-based cross-case analysis are then developed further in the theory building process. This chapter concludes with profiles of the case firms.

Chapter 6 presents the findings from the within-case analysis of one case. This single case serves as an example of the narrative analysis and visual maps used as the starting-point for all cases in this study. This chapter takes the form of analysis of the

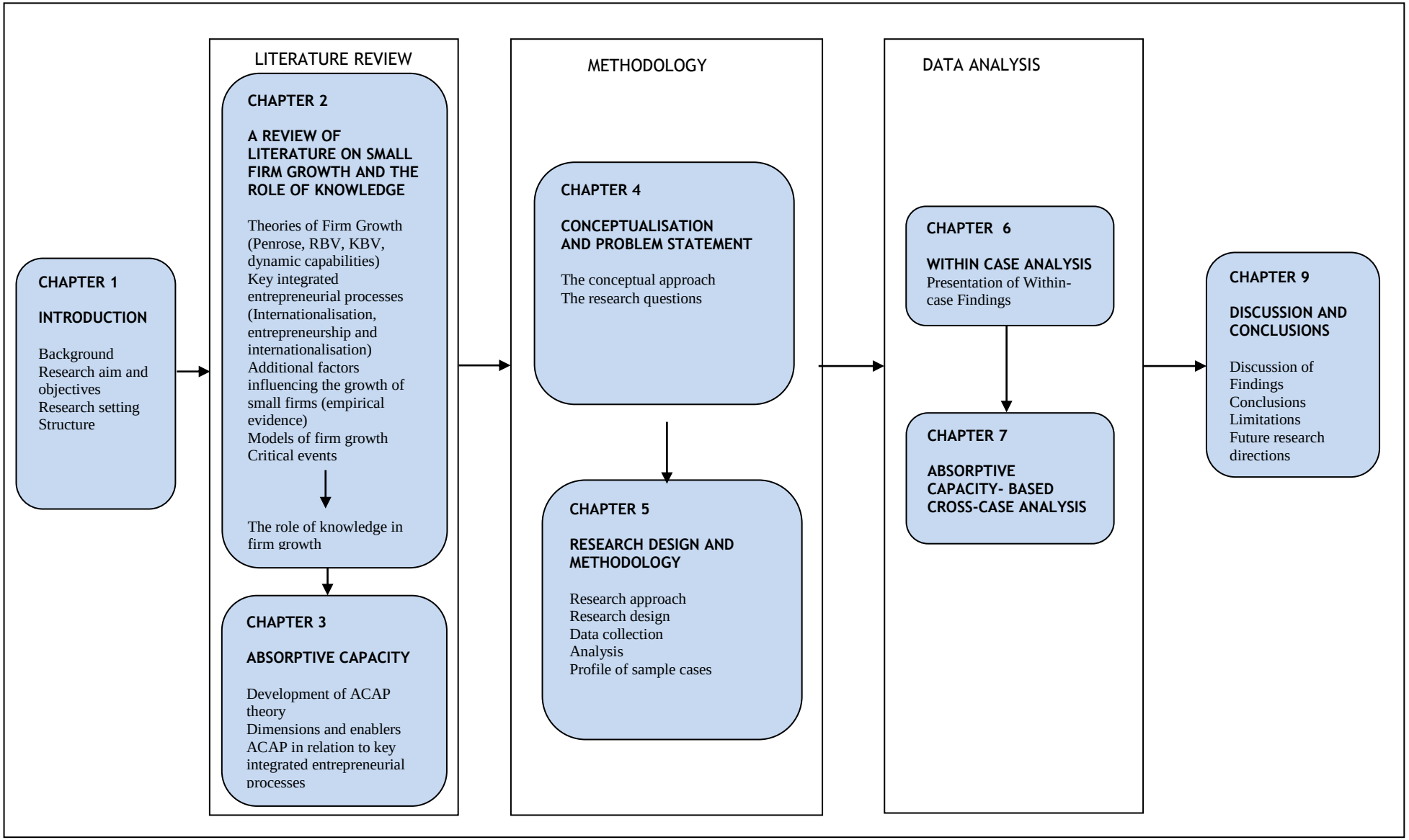


Figure 1.1 Structure of Thesis

leverage of knowledge for each growth challenge associated with the critical event identified by the firm. The key issues that emerge from this case are 1) the critical event for the firm involved all three key drivers of small firm growth; 2) the challenges faced by the firm in relation to this critical event were addressed simultaneously by the firm; 3) the resolution of these challenges involved an iterative process of acquisition, assimilation and transformation of multiple types of knowledge; 4) a number of key enablers of the leverage of knowledge through the ACAP process are identified, in particular social capital, and; 5) the importance of building relationships across the value chain in order to fully understand the industry dynamics and to be able to influence key decision makers is highlighted. Furthermore, this case highlights the important role of the social capital of board members in making appropriate connections for timely knowledge acquisition.

Chapter 7 presents an absorptive capacity-based cross-case analysis of the findings of this research, using the case study analysis methods discussed in Chapter 5. The findings are presented in four main themes:

- The growth challenges faced by the HTNVs in this study
- The leverage of external knowledge by case firms, presented in order of the dimensions of absorptive capacity.
- Key enablers of the leverage of knowledge by HTNVs
- The key enabling role of social capital in leveraging knowledge to overcome challenges.

The key findings that emerge from cross case analysis are as follows. 1) At critical events, HTNVs face simultaneous challenges involving key integrated entrepreneurial processes, which create complex knowledge requirements. 2) At critical events, the speed of resolution is important, and therefore the timely acquisition and application of external knowledge can have an impact on firm growth. 3) This study highlights that the leverage of knowledge is an iterative and cumulative process which builds stocks of different types of knowledge. 4) Key enablers of the four dimensions of the ACAP process are identified, in relation to the growth challenges faced by case firms, highlighting the synergistic nature of enablers. 5) In particular, the key role of social capital is highlighted in enabling the leverage of knowledge to resolve growth challenges.

Chapter 8 concludes this thesis by presenting the key findings of this study and discussing how they compare with and add to the extant knowledge on the leverage of knowledge by HTNVs. The chapter is structured as follows. First, the chapter returns to the research question and articulates answers based on the findings of this study. Then, this chapter moves onto a discussion of the findings, in relation to the extant literature, deriving propositions aimed at advancing theory. In answering the research question, this thesis advances a new process model of absorptive capacity, which makes a significant contribution to the development of ACAP theory. This chapter then highlights key contributions to theory, outlining how this study advances current understanding in the field of small firm growth and absorptive capacity. The contribution of this thesis to managers of HTNVs and policy makers is also discussed. The chapter concludes with the limitations of this research and potential future research directions.

Chapter 2

The growth of high-technology new ventures and the role of knowledge

2.1 Introduction

Small firms, particularly HTNVs, have been shown to be important to national economies, but will only make a significant contribution if they grow and achieve their full potential. As stated in the introductory chapter, this thesis is concerned with the exploration of how HTNVs leverage knowledge to enable their growth and development.

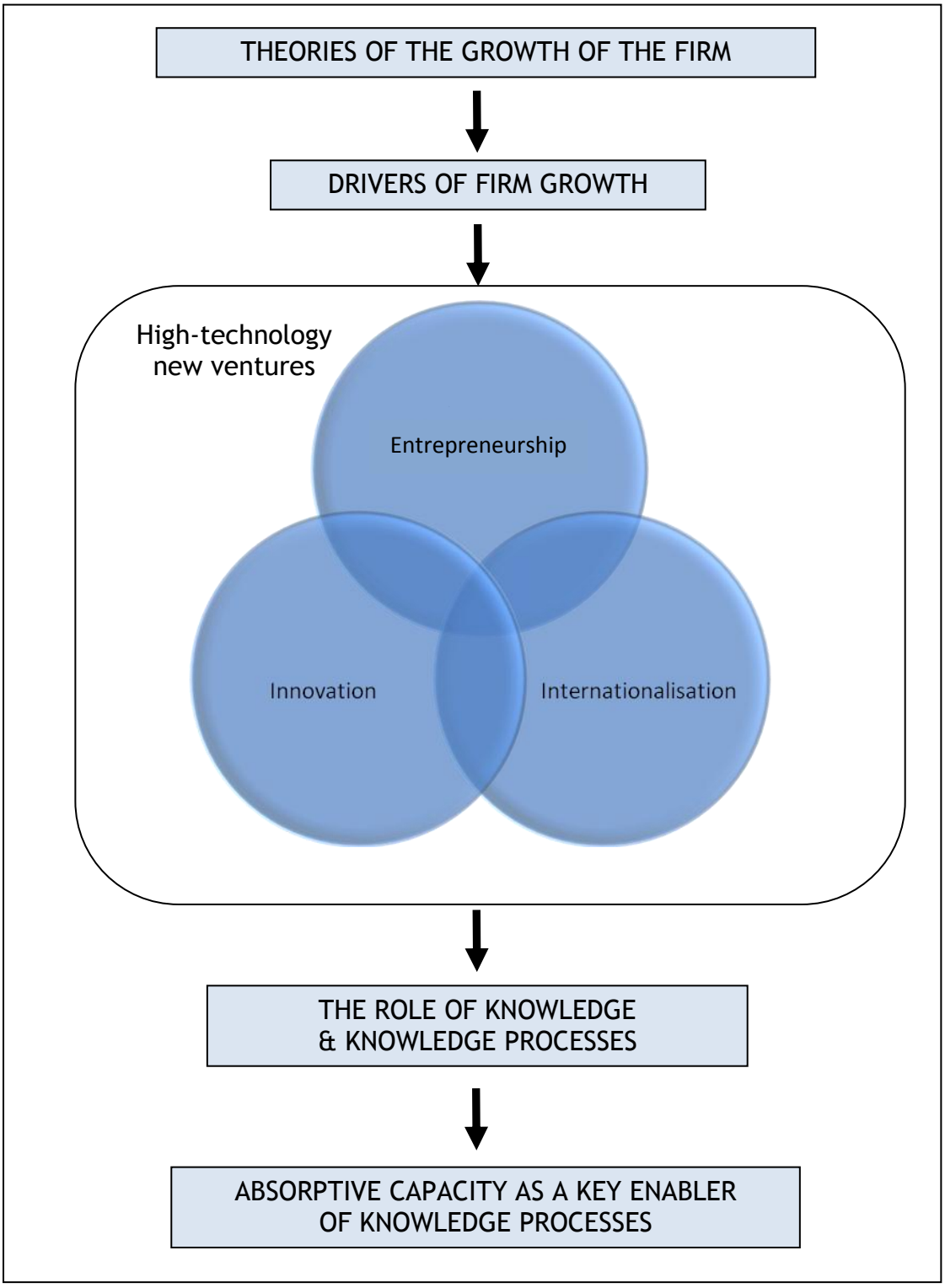
In order for this inductive study to make a meaningful contribution to knowledge in the field, a comprehensive review of the existing literature was undertaken (Hart, 1998), enabling this study to address gaps in the understanding of the leverage of knowledge. This created a strong research focus for this research (Eisenhardt, 1989); however, by exploring the key drivers of small firm growth, this also ensured a holistic approach to the study of the leverage of knowledge to enable growth.

This chapter aims to review the existing literature on the growth of HTNVs. Due to a lack of holistic approaches to the development of HTNVs, this review has been drawn from a number of approaches and fields of study, examining the role of knowledge and knowledge processes in the growth of these firms. A number of searches were carried out in order to ensure all the relevant literature was identified, utilising strategies including keyword searches, published literature reviews searches, key scholar searches, top-ranking publication searches and other sources suggested by academic and work colleagues.

The review first examines the main business growth theories, highlighting the importance of knowledge as a key resource for growth, and the ability to manage knowledge within the firm as an essential management capability. As entrepreneurship, innovation and internationalisation are integral drivers of growth in HTNVs, the literature on these processes is reviewed, also highlighting the significance of knowledge as a moderating factor. The review then focuses on small firms, examining recent empirical evidence for additional factors influencing the growth of small firm. Models of firm growth are also

reviewed, highlighting that the resolution of challenges at critical events enables firms to grow. Figure 2.1 shows the theoretical framework followed.

Figure 2.1 Theoretical framework



Source: Developed by the researcher

A discussion of the important role of knowledge for the growth of the firm, as noted by the theories, follows. This leads on to the conceptualisation chapter, which defines the research question. The characteristics of HTNVs are highlighted as being significantly different to the rest of the small firm population, in that they are created with the specific purpose of maximising the return from the technology upon which they were founded, and as such, aim simultaneously to develop commercial applications of their technology, while expanding in international markets. A review of recent literature on models of firm growth points to the importance of resolving challenges at critical events to enable the firm to grow. It also highlights that the absorption of external knowledge is critical to finding the solutions to challenges faced by HTNVs as they grow, and enabling the transformation of the firm to optimise their value.

This chapter concludes that the review of literature relating to growth across many diverse fields of management all highlight the importance of the leverage of knowledge for the performance and growth of the firm and points to absorptive capacity (ACAP) as being an important capability which differentiates the firm and enhances performance. ACAP is therefore an appropriate research framework to explore the leverage of knowledge by HTNVs; this construct is reviewed in Chapter 3.

2.2 General theories of the firm and the role of knowledge

This section examines general theories of the firm in turn and explores how each theory describes the role of knowledge in the growth of the firm.

2.2.1 The Theory of the Growth of the Firm

Penrose's (1959) seminal text *The Theory of the Growth of the Firm,* is widely acknowledged as one of the most influential books of the second half of the twentieth century, bridging the gap between strategic management and organisational economics (Kor & Mahoney, 2000; Pitelis, 2002). Penrose describes the process of the firm's growth as recurrent periods of expansion of the firm's resource base and administrative structure (Saemundsson, 2005).

Penrose's growth theory of the firm concerns dynamic and path-dependent organisational learning. Penrose (1959) notes the path dependency of resource development, suggesting that the bundle of resources a firm possesses at a given point in time limits the potential service the firm is able to produce. This notion of path dependency is central to the dynamic capability view and the construct of absorptive capacity. Penrose not only articulates how and why the drivers shape the rate and direction of growth, but also argues that ignorance of these limiting factors results in inefficiencies and loss of competitive advantage (Kor & Mohoney, 2004). Rugman and Verbeke (2000, 2004) propose that Penrose (1959) does not make a direct contribution to resource-based thinking, but this is disputed by others, such as Kor and Mahoney (2004), who argue that Penrose makes a distinctive contribution to the modern resource-based view and dynamic capabilities. These theories are described later in this chapter.

Delmar et al. (2003) argue that Penrose is one of the few authors that distinguish between organic growth and growth by acquisition. Penrose (1959) suggests that firms that grow organically will show a smoother growth pattern over time than firms that grow mainly through acquisition. She also suggests that organic growth is associated with smaller, younger firms and emerging industries and that acquisition growth is more likely to occur in older, larger firms and in maturing industries. These suggested relationships have found some support in empirical studies (Levie, 1997; Wilkund & Davidsson, 1999).

Penrose argues that expansion is based on opportunities identified by entrepreneurs within the firm and their managerial capacity to plan and carry out the exploitation of those opportunities, a theme which is also supported by the field of entrepreneurship. Promoting an entrepreneurial vision of managers, Penrose (1959:37) argues: "Here [in the process of growth] the imaginative effort, the sense of timing, and the instinctive recognition of what will catch on or how to make it catch on become of overwhelming importance. These services are not likely to be equally available to all firms. For those that have them, however a wider range of investment opportunities lie open than to firms with a less versatile type of enterprise". This emphasis on the actions of individuals also resonates with the field of entrepreneurship. Penrose suggests that the availability of top management and technical talent serve as a potential blockage for the firm's growth at any

particular time. Penrose also argues that firm's specific experience in the top-management team produces tacit knowledge of strengths, weaknesses and idiosyncratic habits of team members. Kor and Mahoney (2004:187) suggest that without this knowledge, managers cannot function well as a team and are less willing to incur irreversible investments under conditions of uncertainty, due to a lack of confidence in each other's abilities. Penrose suggests that this acts as an isolating mechanism which contributes to competitive advantage. Penrose (1959:390) also notes that firms with an entrepreneurial culture are likely to sustain superior returns, an idea that is expanded upon by Barney (1986a). Rugman and Verbeke (2002:771-774) argue that Penrose has little relevance to the protection of a firm's competitive advantage, but this is refuted by Kor and Mohoney (2004), who note that Penrose's (1959:113-114) emphasis on the time dimension and the protection of current advantage with continued efforts to innovate to renew economic value parallels the core arguments of the dynamic capability view of the firm (Teece et al., 1997).

What does Penrose say about the role of knowledge in firm growth?

Penrose (1959) argues that the ability to identify new productive opportunities is dependent on the knowledge of the firm's entrepreneurs, suggesting that this knowledge will increase during expansion and that firms will always have new possibilities and inducements for further expansion, even if external conditions are unchanged. Penrose (1959:77) holds that managers "shape the scope and direction of the search for knowledge."

The uniqueness of the firm's historical knowledge bases leads the firm to diversify in directions that utilise their excess capacity of competencies. Current knowledge bases and underutilised resources of the firm determine the direction of firm growth (Penrose, 1959:77). The knowledge endowment of the firm and its capacity to learn shapes and limits the rate and pattern of learning a firm can achieve. Penrose explains the role of firm-specific tacit knowledge in the context of firm growth, innovation and diversification. Limitations to the rate of learning at individual, team and firms levels restrict both the rate and direction of growth (Kor & Mahoney, 2004).

For Penrose, expansion is intimately associated with the processes through which knowledge is acquired and applied. A number of scholars have built on this theory,

suggesting that the possession of knowledge defines the shape and trajectory of a firm's growth (Greiner, 1972, 1998; Churchill & Lewis, 1983; Scott & Bruce, 1987), and a lack of managerial resources, or competences, may undermine a small firm's ability to grow (Goffee & Scase, 1995). Penrose (1959:53) notes that "experience produces increased knowledge about things and contributes to 'objective' knowledge in so far as its results can be transmitted to others. However, experience itself can never be transmitted; it produces a change - frequently a subtle change - in individuals and cannot be separated from them." Penrose goes on to observe that managers' experience with their firm-level resources produces firm-specific knowledge about opportunities that are unique to the firm and argues that managers "shape the scope and direction of the search for knowledge" (Penrose, 1959:77), thus shaping the search for new opportunities as described by entrepreneurship scholars.

2.2.2 The resource-based view of the firm

The *resource-based view* (RBV) of the firm, first posited in the literature by Wernefelt (1984), builds upon the theory that a firm's success is largely determined by the resources it owns and controls. The RBV's central focus is the leveraging and exploitation of firm resources to achieve sustainable competitive advantage that in turn creates superior performance (Wernefelt, 1984; Barney, 1986, 1991; Peteraf, 1993). Resources are typically defined as either assets or capabilities that are not freely bought and sold in the spot market. Hinging on the seminal contributions by Knight (1921), Penrose (1959) and Schumpeter (1934), the RBV stream of literature argues that firms are bundles of unique, capabilities that are difficult to imitate. The fundamental premise of the RBV is that organisational competencies, which are heterogeneous and immobile, form the basis of sustained competitive advantage and growth. The heterogeneity of competencies describes the fact that they are unevenly distributed and deployed across any given competitive environment. The RBV suggests that differences in competency endowment and competency deployment accounts for differences in the size distribution and competitive position of firms (Conner, 1991; Rumelt, 1984). The RBV has made a significant contribution to the study of and understanding of the growth of the firm.

What are resources?

The value of an enterprise is made up of physical assets/resources, various financial assets/resources and, finally, intangible assets/resources. In most cases, the terms assets and resources are interchangeable. The concept of resources has been developed further and popularised by macroeconomics scholars as the 6 different types of capital required for sustainable economic growth (financial, physical, intellectual, human, organisational, relational/social). Some authors view human capital, organisational capital and social capital as aspects of intellectual capital, as they all involve the value of knowledge held by the organisation. Empirical evidence relating to the impact of resources on the growth of SMEs is highlighted in section 2.9.

The RBV literature argues that only resources which are valuable, unique/rare (Barney, 1991), inimitable (Dierickx & Cool, 1989) and non-substitutable are capable of generating and sustaining a competitive advantage (Barney 1991). Dierickx & Cool (1989:1509) argue that the existence of substitutes for a given stock of competencies "threaten to render the original asset stock obsolete, typically because they no longer create value for the buyer." Such resources are considered to be strategic, intangible resources (Amit & Shoemaker, 1993; Michalisin et al., 1997). While assets, either tangible or intangible, are controlled by the firm (Colis, 1994), capabilities are intangible bundles of skills and accumulated knowledge exercised through organisational routines (Nelson & Winter, 1982; Teece & Pisano, 1994; Teece et al., 1997). Capabilities are dependent upon the firm's capacity to generate, exchange and utilise the information needed to achieve desired organisational outcomes through the firm's resources (Amit & Shoemaker, 1993). The immobility of competencies means they cannot easily be transferred from one firm to another. For example, organisational culture (Barney, 1996a) organisational routines (Nelson &Winter, 1982) and firm's reputation and image (Wiegelt & Camerer, 1988) are not transferable across organisational settings, due to isolation mechanisms (Rumelt, 1984). Barney (1991) states that the value of a resource depends on the efficiency and effectiveness of its use in exploiting opportunities and neutralising threats. The RBV views alliances and acquisitions as mechanisms for exploiting existing firm-specific assets.

Thomke & Kuemmerle (2002), while agreeing with the basic premise of the RBV, argue that little is known about the processes by which such assets are built. Their empirical study of the accumulation of chemical libraries and related technological assets by pharmaceutical companies demonstrated that it is the subtle complex differences in the way firms build or adopt their assets which makes them difficult to imitate by others. They found that new technologies of high throughput screening and combinatorial chemistry made chemical libraries more valuable, which in turn made the technologies more valuable. This interdependence of assets supports the view of Teece (1986) and Dierickx & Cool (1989) among others, who suggest that because of complementarity, co-located bundles of assets are of more value than the sum of disjointed assets. Other critics suggest that RBV reaches a boundary condition in high velocity environments, such as life sciences, because it emphasises exploitation of current competencies rather than the acquisition of new knowledge (Eisenhardt & Martin, 2000). This shortcoming of the RBV is developed in the *dynamic capability* literature described in Section 2.4.4

What does the RBV say about the role of knowledge?

The RBV is unequivocal about the role of knowledge in creating competitive advantage (Barney, 1991). A firm whose employees have unique abilities, knowledge or foresight to make an accurate assessment of a strategic resource's earning potential may achieve superior economic benefits relative to those firms that lack such abilities, knowledge or foresight (Barney, 1986b). However, the RBV treats knowledge as a generic resource rather than having special characteristics, and does not distinguish between different types of knowledge-based capabilities. This further developed in the knowledge-based view of the firm described in section 2.2.3.

2.2.3 The knowledge-based view of the firm

The knowledge-based view of the firm (KBV) extends and builds on the RBV of the firm because it examines both the exploitation of existing firm resources and the firm's ability to develop new capabilities and access knowledge beyond firm boundaries (Grant & Baden-Fuller, 2004). This perspective on firm growth considers knowledge to be the most strategically significant resource of the firm. Its proponents argue that because knowledge-

based resources are usually difficult to imitate and socially complex, heterogeneous knowledge bases and capabilities among firms are major determinants of sustained competitive advantage and superior performance. Knowledge is embedded and carried through multiple entities including organisational culture and identity, routines, documents, systems and employees (e.g., Spender, 1996a; Lemon & Sahota, 2004).

What does the knowledge-based view say about the role of knowledge?

Grant (1996a) and Spender (1996a) propose that knowledge is one of the most strategically significant resources of the firm and the foundation element of valuable intangible organisational resources and capabilities. Spender (1996a:47) highlights the role of the individual in the knowledge processes of the firm, arguing that "organizations are enduring alliances between independent knowledge creating entities, be they individuals, teams or other organizations" and argues that collective knowledge lies at the heart of the firm's competitive advantage. Drawing on Penrose's (1959) theory of the firm, he points to the coordinating capacity of management as being the impetus to growth. Grant also argues that the success of the firm is solely dependent on knowledge and knowhow of its employees (Grant, 1996b). This view is echoed by Castanias & Helfat (1991) and Lado et al. (1992) who suggest that firm performance is critically linked to the skills, expertise and know-how of managers. McEvily and Chakravarthy (2002) take this forward suggesting that knowhow generates more durable advantages than any other resource. However, the KBV as criticised as not really addressing knowledge as a process and investigate the consequences of path dependency or power (Carlile, 2004). Information technology plays an important role in the knowledge-based view of the firm, in that information systems are viewed as being able to synthesise, enhance and expedite large-scale intra and inter-firm knowledge management (Alavi & Leidner, 2001).

The KBV literature has primarily focused on the role of firms in providing efficient knowledge exchange rather than their role in efficiently producing knowledge or capabilities. Nickerson and Zenger (2004:617) critique this approach, suggesting that "the key knowledge based question that a manager faces is not how to organise to exploit already developed knowledge or capability but rather how to organize to efficiently generate knowledge and capability." The RBV views alliances and acquisitions as

mechanisms for exploiting existing firm-specific assets. However, critics from the dynamic capability field suggest that RBV reaches a boundary condition in high velocity environments because it emphasises exploitation of current competencies rather than the acquisition of new knowledge (Eisenhardt & Martin, 2000).

An additional criticism of the KBV by Nickerson and Zenger (2004) includes the fact that a fundamental argument within the literature that support efficiency of knowledge exchange relative to markets are fully contradictory. One claim that hierarchies exist to essentially avoid knowledge transfer (Demsetz, 1988; Conner, 1991; Conner & Prahalad, 1996), the other view suggests that hierarchies exist to facilitate knowledge transfer (Arrow, 1974; Kogut & Zander, 1992, 1996; Nahapiet & Goshal, 1998). Nickerson & Zenger (2004) posit that although agreeing with the KBV that it is the managers role to create valuable new knowledge, the manager cannot simply choose new knowledge to acquire as often the knowledge doesn't exist. They draw on earlier work by Fleming & Sorenson (2000, 2004) and Henderson & Clark (1990) who posit that solutions to complex problems represent unique combinations or synthesis of existing knowledge, and argue that managers should choose valuable problems to solve, which if successfully solved yield desirable knowledge or capability" (Nickerson & Zenger, 2004:618).

Strategy literature that explores the variation in firm performance has highlighted the role of the resources or capabilities of the firm as sources of firm competitive advantage (Fabrizio, 2009). This is especially the case when these capabilities are difficult to imitate and are not available through a market transaction. In the fast pace of technological and scientifically based innovation in high-technology firms, knowledge utilisation needs to be as intentional, methodical and effective as the utilisation of any other resources (Drucker, 1993). Knowledge plays a key role in all other factors that impact on growth, so cannot be seen independently.

2.2.4 Dynamic capabilities view

The key argument of the dynamic capabilities view is the importance of firm's ability to respond efficiently and promptly to external market changes, and dynamic capabilities are "the tools that manipulate resource configurations" (Eisenhardt & Martin, 2000:1118). The RBV literature has been expanded upon to address the concern that RBV had not adequately explained how and why certain firms can achieve competitive advantage in a market with rapid and unpredictable changes (e.g., Eisenhardt & Martin, 2000; Makadok, 2001; Teece et al., 1997; Winter, 2003). Capabilities are argued by many scholars to be the preeminent sources of firm growth and success (Day, 1994; Michalisin et al., 1997; Teece et al., 1997; Srivastav et al., 1998; Devinney et al., 2001), and include knowledge process and organisational learning (Teece et al., 1997), opportunity recognition.

Teece et al. (1997:516) define the concept of dynamic capabilities as "the firm's ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments". Building on Nelson and Winter's (1982) view of the organisation as a set of interdependent operational and administrative routines which slowly evolved on the basis of performance feedbacks, Zollo and Winter (2002:340), redefined the construct as "a learned and stable pattern of collective activity through which the organisation systematically generates and modifies its operating routines in pursuit of improved effectiveness", emphasizing the importance of learning. It also highlights that dynamic capabilities are built rather than bought (Makadok, 2001). More recently, Helfat et al. (2007) suggest that a dynamic capability represents a higher order ability to sense and address a need for change in an organisation's competence base. Organisational learning is important for the effectiveness and efficiency of resource management in dynamic environmental conditions, to create value (Sirmon, Hitt & Ireland 2007:275). This builds on Zahra and George's view that "organizational learning provides firms with a potential capacity for strategic flexibility and the degrees of freedom to adapt and evolve" (2002b:185).

Newey and Zahra (2009:S96) point to the importance of dynamic capabilities in entrepreneurship, in reconfiguring operating capabilities to respond to both market opportunities and risks due to exogenous shocks. Drawing on Penrose (1959), dynamic

capabilities emphasise the manager's role in integrating and combining and utilising resources to generate value-creating strategies and to respond to market changes (Henderson & Cockburn, 1994; King & Tucci, 2002; Helfat et al., 2007). Sapienza et al. (2006) posit that to some degree, firms can substitute management experience for lack of organisational experience. Autio et al. (2001) suggest that resources can cause constraints and foster problems for firm growth. Drawing on this, Sapienza et al. (2006) suggest that resource fungibility (i.e., the extent to which the resources may be adapted and redeployed for alternative uses at a low cost) has a moderating effect on survival and growth by allowing firms to re-allocate resources to generate new routines, thus maintaining the strategic flexibility that is crucial for survival and growth.

In dynamic industry environments, investment in R&D activities is one method firms may use to gain advantage over their competitors (Pavitt & Patel, 1988), and which enhances the firm's ability to develop and exploit technical know-how (Pisano,1990). This ability to exploit stocks of technological know-how through ongoing R&D investment is important in the development of future innovations (Dierickx & Cool, 1989), thus building on Penrose's (1959) view that innovation (R&D) is a key driver of growth. Sapienza et al. (2006) also argues that during early stages of internationalisation, new ventures develop capabilities that increase the probability of growth. A key question for dynamic capability scholars is whether capabilities enhance firm performance and whether this performance effect persists over time. Teece, Pisano & Shuen (1997:515) emphasise the path dependency of dynamic capabilities stating that it "not only defines what choices are open to the firm today, but... also puts bounds on what is internal repertoire is likely to be in the future."

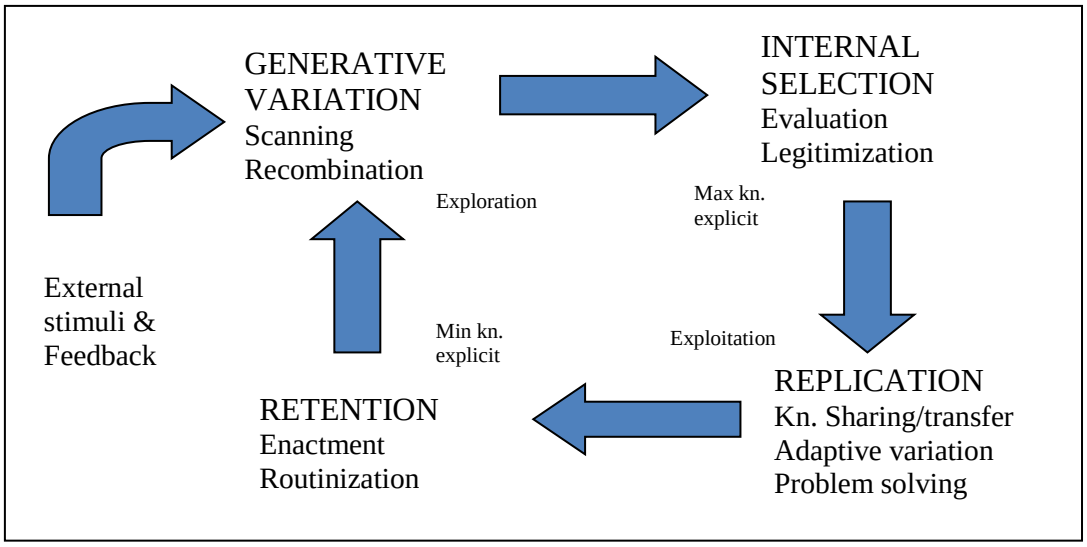
What does the dynamic capabilities view say about the role of knowledge?

Drawing on the KBV, Eisenhardt and Martin (2000:1109) point to knowledge creation processes as a key dynamic capability. They argue that in high-velocity markets, capabilities rely extensively on new knowledge created for specific situations. As new knowledge must be gained rapidly in each new situation, organisations engage in experiential activities such as prototyping, real-time information gathering, and experimenting that generate immediate knowledge. In order to adapt to changing

information, routines are adaptive, iterative and cognitively mindful, shaped by learning mechanisms. Zollo & Winter (2002:339) link the creation of dynamic capabilities to three sets of learning mechanisms: 1) experience accumulation; 2) knowledge articulation and; 3) knowledge codification, and suggest that dynamic capabilities are shaped by the co-evolution of these mechanisms. They argue that knowledge codification is an important but relatively underemphasised element in the capability-building picture. This builds on earlier work suggesting that codification, via the creation of a manual or tool, facilitates the diffusion of existing knowledge (Winter, 1987; Zander & Kogut, 1995; Nonaka, 1994).

Zollo and Winter (2002) argue that the principal benefits of the codification effort are seen as coming from the successful use of the manual or tool created (see Figure 2.2). They also discuss the learning benefits that come from the articulation process which is a precursor to the codification process itself. They introduce the knowledge evolution cycle and the relationship between learning, the creation of routines and dynamic capabilities. Winter (2003), as he further progresses the idea of capability hierarchy, reemphasises the importance of learning.

Figure 2.2 Activities in the knowledge evolution cycle



Source: Zollo & Winter (2002:343)

Winter's (2003) second order of dynamic capabilities is associated with single-loop learning and first-order change as they effect changes to the resource base, but the way the changes are performed does not change. However, Winter's (2003) higher order of dynamic capabilities is related to double-loop learning and second order change as they are

transformational in nature. Routines are carried out tacitly by individuals and across teams, and therefore act as a critical facilitator of what the firm does and how it does it (Zollo & Winter, 1999). The concept of knowledge tacitness originates from the work of Polanyi (1967) and is defined by the extent to which knowledge can be codified and explicitly communicated. He proposed that tacit knowledge cannot be easily exchanged or shared and is deeply rooted in a specific context. Several researchers (Michalisin et al., 1997; Johnson & Scholes, 1999; Teece, 2000) acknowledge that capabilities are tacit in nature because they are inextricably embedded in organisational experience, learning and practice.

As the role of organisational learning was being emphasised by RBV scholars, and the field of dynamic capabilities was emerging, Cohen and Levinthal (1990) introduced the construct of absorptive capacity (ACAP) arguing that R&D intensive firms are also able to more effectively exploit external knowledge as a result of its internal R&D efforts. This is echoed by Slater (1997) and Dyer & Singh (1998), who argue that the capabilities of the firm are largely reflective of the knowledge sharing and learning ability of the firm. Newey and Zahra (2009:85) see ACAP as "a key knowledge based capability underpinning the functioning of both operating and dynamic capabilities". The greater a firm's ability to exploit external knowledge the greater will be the pool of knowledge available to the firm in the future. The ability to exploit external knowledge has been shown to be of particular importance to firm performance and growth and ACAP has also been highlighted as a key enabler of the knowledge processes within the firm. The construct of ACAP is explored further in Chapter 3.

2.3 Growth of small and medium sized firms

Small and medium-sized enterprises (SMEs), defined as having fewer than 250 employees, make up a large part of Europe's economy, accounting for 99% of all enterprises. SMEs are a major source of entrepreneurial skills and innovation and are thought to be indispensible for the delivery of stronger, lasting [economic] growth (Commission for European Communities, 2005:3). The EU has set itself the objective of "strengthening the innovation and research capacity of SMEs and increasing the volume of technology transfer to them" (Commission for European Communities, 2005:9).

Growth helps to establish legitimacy, achieve economies of scale, attract investment capital and increase profitability (Nicholls-Nixon, 2005). The RBV suggests that SMEs should pursue entrepreneurial strategies that focus on the accumulation of intangible resources for survival and growth. Strong growth of SMEs has been found to reduce profitability in the short term, but increases it in the long-term (McDougall et al., 1994). Davidsson et al. (1993) found that most new jobs were created by existing SMEs rather than new SMEs and others have found that SME growth is closely associated with a firm's overall success and survival of the firm (Johannisson, 1993; Phillips & Kirchhoff, 1989).

Other scholars note that growth is a critical precondition for the achievement of other financial goals by SMEs (de Gues, 1997) and for their longevity (Storey, 1994:158). Different growth strategies may require different resources and have different performance implications (Kor, Mahoney & Michael, 2007). Small firms must be adaptive to overcome their vulnerability (Aram & Cowen, 1990), a liability arising from their smallness (Bruderl & Schussler, 1990). However, small firms may be more willing than older firms dynamically to develop the capabilities required to compete effectively in international markets.

There has been significant interest in the study of SME growth and a number of SME growth processes have been described in the literature. Birch (1984:8) suggested that it is "better to think of them [small firms] as a large collection of small seeds, few of which sprout and become large plants". Many SMEs pursue a strategy which implies a clear

limitation to growth. A key message emanating from strategic management literature is that not all SME owner-managers have the desire, or indeed the capability in terms of resources and expertise, to grow their business (Stanworth & Curran, 1986; O'Farrell & Hitchens, 1988; Davidsson, 1989; Birley & Westhead, 1990; Frank et al., 1991). It should be noted that these firms still make a valuable contribution to the economy and society despite their lack of growth.

The main contribution to job creation comes from a smaller number of fast-growing companies. For example, Birch notes that in the period 1981-1985, just 18% of firms were responsible for 86% of new jobs. Birch termed these companies that sustain rapid growth for an extended period of time 'gazelles'. The emerging literature stream on gazelles finds that they exist in all industries, not specifically in high-technology sectors. Recent studies of gazelles in the USA (e.g., Henrekson & Johansson, 2010; Acs et al., 2008; Nicholls-Nixon, 2005) refer to them as high impact firms, with sales that have at least doubled over a four-year period and have an employment growth quantifier. Although gazelles account for only 3% of firms in the US, they make a disproportionate contribution to wealth creation and employment and are seen as the goal to be pursued. Therefore, the study of small firms that grow rapidly and make a more significant contribution to the economy, are of great interest to researchers and policy makers. Despite the significant interest in the growth of SMEs for almost five decades, Leitch et al. (2010) argue that little is known about SME growth and conceptual development is limited. McKelvie &Wilklund (2010) provide a useful summary of the three main streams of growth research, concluding that there is a need to focus more on 'how' firms grow instead of 'how much' in order to better understand the phenomenon.

2.4 Growth of HTNVs

HTNVs are generally established to exploit a new technological platform and as such are founded with the explicit intension to grow and maximise the return on investment for shareholders. HTNVs are characterised by the importance of technology to the strategy of the firm (Kazanjian & Drazin, 1989), and competitive advantage is often a result of technological differentiation. A main concern of HTNV is the need to be continually engaged in adaptive thinking (Bantel, 1997) in order to stay at the leading edge of the

dynamic industries in which they operate. This indicates that the efficiency of knowledge acquisition and the speed of exploitation is a key factor in the growth of HTNVs. Covin, Prescott & Slevin (1990) found that firms in high-technology industries do have more organic structures, and are more likely to have an entrepreneurial strategy, (defined as one reflecting innovativeness, pro-activeness and risk-taking), compared to firms in low-technology industries. The distinctive capabilities and competencies of HTNVs are closely related to the human capital (i.e. skills and knowledge) of their founders (Cooper & Bruno, 1997; Feeser & Willard, 1990; Colombo & Grilli, 2005) and their ability to leverage knowledge. The origins of the firm (academic spin-out, corporate spin-off, or independent start-up) and resulting experience in the management team can have a considerable impact on the development and growth of HTNVs.

Due to the high cost of technology development, financial constraints can prevent some high potential HTNVs from growing as fast they would with adequate financing (Carpenter & Petersen, 2002). HTNVs tend to require business angel and venture capital funding as they grow, and therefore develop more formal management structures. For example venture-backed companies are likely to consist of entrepreneurial teams comprising both technically- and commercially-oriented management (e.g., Colombo & Grilli, 2009). As many HTNVs are not profit-making while they are developing their product, effective financial management while they are in 'cash burn' mode is important for survival.

Colombo and Grilli (2009) note that previous studies which have analysed the effects of VC funding on growth have generally highlighted a positive relationship (Audretsch & Lehmann, 2004; Engel & Keilbach, 2007), although there are some exceptions (Bottazzi & DaRin, 2002). HTNVs often need to internationalise their activities at a very early stage due to the limited but global nature of the technological market niche that they were set up to exploit (Keeble et al.,1998). This is discussed further in section 2.9.

Growth of HTNVs is difficult to achieve, with many remaining small several years after their establishment (Colombo & Grilli, 2009). Most HTNVs are not gazelles. Although some of the subjects of Henrekson and Johansson's (2008a) study are in high-technology sectors, and are considered to be small firms (fewer than 500 employees), they are

significantly different to the average small HTNV employing between 10 and 50 employees.

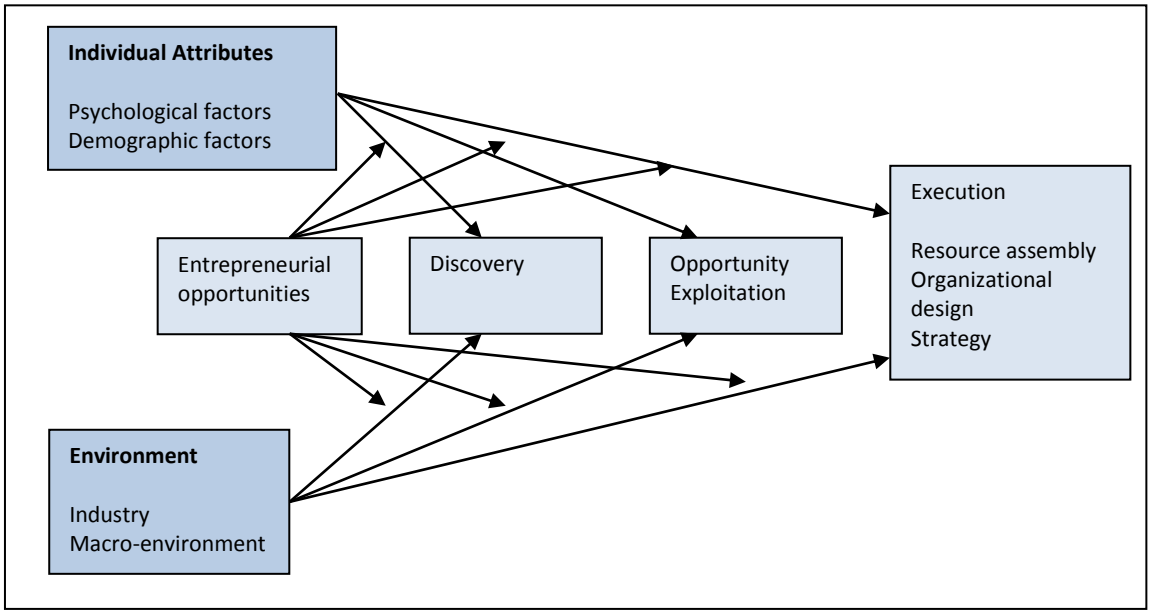
The following three sections discuss entrepreneurship, innovation and internationalisation as drivers of small firm growth and Section 2.10 expands on the additional factors, both internal and external, that have been highlighted, by empirical studies, as impacting on SME growth. Each factor links back to the importance of knowledge which has already been highlighted in the reviews of the general theories of growth. Over time, the effective pursuit of growth can be hampered by competency traps (Cohen & Levinthal, 1990). It is perceived that competency traps become more acute with time because of the path-dependent nature of knowledge and can limit the firm's ability to recognise and pursue new opportunities.

2.5 Entrepreneurship as a driver of firm growth

2.5.1 What is entrepreneurship?

Entrepreneurship is central to the performance of individuals in the creation and growth of new small ventures (Shane and Venkataraman, 2000). Although the field of entrepreneurship originated in the study of individuals who created new ventures, the concept has been expanded more recently. Survival and growth are considered by Shane (2003) to be primary operational measures of entrepreneurial effort, as very few entrepreneurial ventures survive, along with profitability and reaching IPO[1]. Venkataraman (1997:120) defines entrepreneurship as a scholarly field which "seeks to understand how opportunities, to bring into existence 'future' goods and services, are discovered, created are exploited, by whom and with what consequences". He proposes that "two issues are of particular interest to scholars in entrepreneurship: sources of opportunities and the nexus of opportunity and enterprising individuals." and suggests (1997:121) that the key questions that entrepreneurship addresses are: "1. Why, when and how opportunities for the creation of goods and services come into existence; 2.Why, when and how some people and not

Figure 2.3 A model of the entrepreneurship process



Source: Shane (2003:11)

[1] IPO explained in Glossary of Terms in Appendix 3

others discover and exploit these opportunities; and 3.Why when and how different modes of action are used to exploit entrepreneurial opportunities." Shane's (2003) model, describing the entrepreneurship process (Figure 2.3), places great importance on the role of the individual in the discovery of opportunities. The entrepreneurial process involves the identification and evaluation of opportunity, the decision whether or not to exploit it, the efforts to obtain resources, and the process of organising those resources.

The field has been expanded to include firm level entrepreneurship. Sharma and Chrisman (1999:18) defined Corporate Entrepreneurship (CE) as "the process whereby an individual or group of individuals, in association with an existing organization, create a new organization or instigate renewal or innovation within that organization." More recently, Ireland et al. (2009:21) define CE strategy as a "vision directed, organization-wide reliance on entrepreneurial behaviour that purposefully and continuously rejuvenates the organization and changes the scope of its operations through the recognition and exploitation of entrepreneurial opportunity". Building on Schumpeter's (1934) emphasis on innovation, the ten definitions of CE highlighted in Sharma & Chrisman's (1999) review of the literature all focus on innovation and the relatedness of innovative activities to the core activities of the firm.

2.5.2 Entrepreneurial opportunities

Shane (2003) explores the source of entrepreneurial opportunities, and reviews two perspectives of earlier scholars (See Figure 2.1). Kirzner (1973, 1985, 1997) argues that the existence of opportunities requires only access to existing information. In contrast, Schumpeter (1934) suggests that new information is important in explaining the existence of entrepreneurial opportunities. Shane and Venkataraman (2000) suggest that the two types of opportunities can be present in the economy at the same time and have different effects on economic activity.

Sources of entrepreneurial opportunities are technological change, political regulatory change and social/demographic change (Shane, 2003). The concept of technological opportunity was originally proposed by Nelson and Winter (1977) to capture increasing returns to R&D (Nelson & Winter 1982). An important insight in the literature of

technological opportunities is that the levels of technological opportunities vary significantly across industries and sectors (Shane, 2003), depending on the vitality of the underlying scientific and technological fields (Palmberg, 2004). This is particularly relevant to HTNVs within the life science industry. Technological opportunities determine the productivity of R&D and provide the incentive for organisations to engage in innovation. For example, the increasingly specialised knowledge and the capability to continuously generate new scientific insights have become the key to competitive advantage in the pharmaceutical industry (Brusoni et al., 2005), highlighting that firms struggle to keep abreast of developments in a number of specialised bodies of scientific and technical knowledge that provide them with innovative opportunities.

Table 2.1: Schumpeterian versus Kirznerian opportunities

SCHUMPETERIAN OPPORTUNITIES	KIRZNERIAN OPPORTUNITIES
Disequilibrating	Equilibrating
Requires new information	Does not require new information
Very innovative	Less innovative
Rare	Common
Involves creation	Limited to discovery

Source: Shane (2003:21)

The window of opportunity within which time a HTNV can make profit from its R&D effort is usually limited (Burgel et al., 2000). Rogers (2001) argues that combining technology and an appropriate opportunity is key for commercial success. Companies must exploit their competitive advantage quickly in order to generate rapid growth path (Aghion & Howitt, 1992). If firms experience delays, their technology-based competitive advantage will be eroded. The uneven patterns of technical progress found in industry can be largely explained by the differences in technological opportunities that firms probe into during innovation (Dosi, 1988; Klevorick et al., 1995). Many studies have shown that entrepreneurs use networks to get ideas, gather information, get informal advice (Baum, Calabrese and Silverman, 2000; Birley, 1985; Birley et al., 1991; Freeman, 1991; Hoang & Antoncic, 2003; Jarillo, 1989). Shane (2003, 2004) and Rothwell (1991) show that being actively engaged in informal networks allows small companies to link into research and development opportunities and alliances.

Entrepreneurial opportunities always involve innovation, but the form of exploitation is not restricted to new products and services. Shane (2003) commends Schumpeter's (1934) innovation typologies to categorise the form that entrepreneurial opportunities take. These are outlined in section 2.6.2.

2.5.3 Exploitation of entrepreneurial opportunities

The successful exploitation of entrepreneurial opportunity necessitates that people to act on the opportunities they have discovered within the window of opportunity, and requires the acquisition and recombination of resources. This activity must be financed until the sale of output from that recombination, and therefore the sourcing of adequate financial capital from investors is key to exploitation. Although individuals discover opportunities, the mode of exploitation typically involves creating an entity or using market mechanisms to exploit the opportunity. The choice of exploitation mode is dependent on a number of factors, including knowledge conditions, demand conditions, industry life cycles, appropriability conditions and industry structure. Where large scale investment is required to fully exploit an opportunity and the value chain in the industry is complex, small firms are more likely to license opportunities to larger firms. Entrepreneurial opportunities are uncertain because resources need to be obtained and recombined before the profitability of the recombination is known (Arrow, 1974). Entrepreneurial strategy involves firstly, developing a competitive advantage that precludes the dissipation of the opportunity to competitors once the entrepreneur has begun to exploit it; and secondly, managing the uncertainty and information asymmetry present in the process of exploiting the opportunity as the entrepreneur/firm seeks to generate value from it (Shane 2003:217).

2.5.4 Organisational responsiveness

A key aspect of the survival and growth of ventures is the ability to adapt and respond to changes in the environment. Organisational responsiveness is key to exploiting opportunities. The concept of organisational responsiveness refers to the action taken in response to relevant information acquired and subsequently disseminated (Kohli, Jaworski, & Kumar, 1993). A key theme in the entrepreneurship literature has been the attempt to identify the forces that promote and transform organisations in response to environmental change (Liao, Welsch, & Stoica, 2003). Organisational responsiveness goes through distinct stages of knowledge and responsive action that flow to form a knowledge chain

(Spinello, 1998). Two key components of the knowledge chain are awareness and responsiveness. Companies must not only have the information and knowledge, but also the capacity and willingness to act in a timely manner. Knowledge management scholars are often guilty of ignoring the latter, being preoccupied with an organisation's intellectual prowess (Davenport & Prusak, 1998; Johnson, 1995). HTNVs typically operate in dynamic industry environments where constant learning is essential for survival. Manager's flexibility in reconfiguring, developing and deploying resources during a period of environmental uncertainty is important for organisational performance (Sirmon et al., 2007). Phan (2006) suggests that this flexibility requires experimentation, a process that can stimulate organisational learning through the acquisition of new knowledge and then use it to build capabilities and capture the value from this entrepreneurial activity.

Shane (2003) commends an interdisciplinary approach to the study of entrepreneurship, considering all aspects of innovation (product, process and organisation) within the firm. Acknowledging that many new ventures have international operations from the outset, internationalisation is an integral part of entrepreneurial strategy (Jones, 1999), an approach which this thesis embraces in an integrated entrepreneurship approach developed in the conceptualisation chapter.

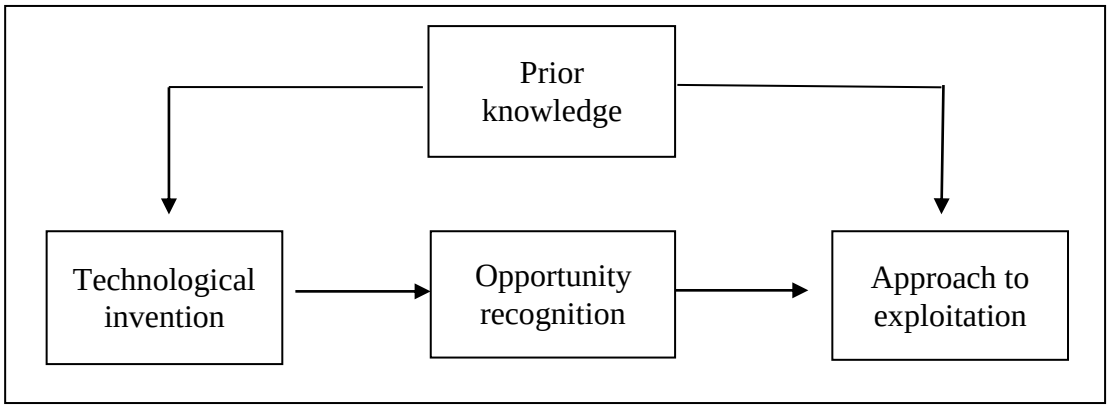
2.5.5 The role of knowledge in entrepreneurship

Knowledge has been highlighted as being key to entrepreneurship by both early entrepreneurship scholars such as Kirzner (1973, 1979) and more recent scholars such as Shane and Venkataraman (2000). Knowledge is central to the entrepreneurship process and organisational learning is a way of increasing the stocks of knowledge within the firm, which in turn reduces uncertainty. A review of the role of knowledge in entrepreneurship literature is summarised in table 2.4. Harrison and Leitch (2005:357) make the distinction between "knowledge – that which is known, and learning – the process by which knowledge is generated. Building on both the RBV and KBV of the firm, Shane and Venkataraman (2000:219) posit that "Entrepreneurship is the means by which knowledge is converted to product and services", while Kazanjian et al. (2001:173) argue that "knowledge is a critical resource and organizational design is a capability that leverages

knowledge in the service of innovation and venturing that is the hallmark of corporate entrepreneurship".

Shane (2000) highlights the importance of the prior knowledge of individuals in the opportunity recognition process (see Figure 2.4), and points to opportunity recognition being a function of the way in which knowledge is dispersed in society (Hayek, 1945), a view supported by Dew et al. (2004). These include prior knowledge of ways to service markets, prior knowledge of customer problems and prior knowledge of markets. Shane (2000) and Venkataraman (1997) suggest that individuals who have developed particular knowledge through education and work experience will be more likely than others to discover entrepreneurial opportunities in response to a given technological change. They are also likely to be better able to exploit the opportunity. "Entrepreneurs are exceptional learners. They learn from everything. They learn from customers, suppliers, especially competitors. They learn from employees and associates. They learn from other entrepreneurs. They learn from experience. They learn by doing. They learn from what works, and more importantly, from what doesn't work" (Smilor, 1997:334). Prior industry knowledge about how a product or a technology influences a particular market can enable one to identify an entrepreneurial opportunity (Roberts, 1991). Market knowledge is not likely to be publicly known but can be acquired by having worked in a particular market (Shane, 2000). An accurate understanding of user needs has been shown to be essential to successful new products. Roberts (1991) suggested that if individuals lack familiarity with customer problems, it is difficult for them to identify solutions to those problems when they are presented. Westhead and Wright (1998a, 1998b, 1999) and Ucbasaran et al. (2003) found that growth was more prevalent in firm founded by habitual entrepreneurs than novice entrepreneurs. Westhead, Wright & Ucbasaran (2001) found that international expansion was more likely in firms with founders with previous international experience, echoing the view of the International New Venture (INV) theory of internationalisation (see section 2.9.3). Knowledge conditions influence the level of entrepreneurial opportunity present in an industry, and include factors such as R&D intensity of the industry, the reliance of innovation by small firms, the degree to which industry relies on public sector institutions to innovate, and the level of uncertainty in the industry (Shane, 2003:143).

Figure 2.4 The effect of prior knowledge on entrepreneurship



Source: Shane (2000:453)

Opportunity recognition is an iterative process through which insights are contemplated, new information is collected and considered, and knowledge is created over time (Lumpkin & Lichtenstein, 2005:457). Marvel and Lumpkin (2007) argue that opportunity recognition is a knowledge based process, which begins with a mix of knowledge and calls on additional knowledge to facilitate the process. They describe the four types of prior knowledge as 1) ways to serve markets, 2) customer problem, 3) markets, and 4) technology. This discussion of mixing experience with new knowledge echoes the thoughts of absorptive capacity literature, where prior experience is seen as an important antecedent to the assimilation of knowledge.

Ucbasaran, Westhead and Wright (2001) suggest that limited research had been conducted on how entrepreneurs utilised the knowledge they had acquired. Developing the theme of the entrepreneurial process, they highlight opportunity recognition and information search and entrepreneurs' ability to make connections between various elements of knowledge that have not been previously connected. Building on this, Zahra and Filatochev (2004:894) suggest that the ability to change in response to the environment is "underpinned by managers' knowledge and learning capacity that directly affects the quality and timing of strategic decisions." The entrepreneurship literature stream reinforces Penrose's view of the key role of managers in acquiring and utilising knowledge. Zahra et al. (2009) build on this suggesting that threshold firms can use board directors as a means

Table 2.2 A literature review of the role of knowledge in entrepreneurship

Author	The role of knowledge	Field
Schumpeter (1934)	New information is important in explaining the existence of entrepreneurial opportunities.	E
Kirzner (1973, 1979, 1985, 1997)	"Entrepreneurial alertness is the "the knowledge of where to find market data." (1973: 67) Kirzner defined entrepreneurial knowledge as " a rarefied, abstract type of knowledge – the knowledge of where to obtain information or other resources and of how to deploy it" (1979: 8) Knowledge, obtained in a particular knowledge corridor that leads to some profit making insight. (1985) The process of discovery can be driven by recognition of knowledge already possessed rather than by search for knowledge needed. (1997)	
Minniti & Bygrave, (2001)	"Entrepreneurial discovery" transforms the entrepreneur's knowledge and is itself a change in the entrepreneur's stock of knowledge." (:7) "Each entrepreneur organizes past experiences in a set of information that, at any point in time, determines his stock of knowledge. An entrepreneur's stock of knowledge is moulded by subjective circumstances and his interests determine which elements of his knowledge are relevant to him and his purposes. "(:7) The decision taken by the entrepreneur is a function of two sets of knowledge: direct knowledge for a specific market and general knowledge of 'how to be entrepreneurial'(:13) 'knowledge is gained from successes as well as from failures." (:13)	E
McGrath (1999)	Entrepreneurs learn from failures.	KBV
Drew et al. (2004)	"Knowledge is dispersed and specific to individuals and this explains how this contributes to the creation of routines." (:677)	E
Hayek (1945) in Venkataraman (1997)	A central feature of a market economy is the partitioning of knowledge among individuals, such that no two individuals share the same knowledge or information about the economy.	E
Venkataraman (1997)	Different people will discover different opportunities in a given technological change because they possess different prior knowledge. "Knowledge that leads to the discovery of an opportunity is "diffused in the economy and is not a 'given or at everyone's disposal" (:122) "The possession of useful knowledge varies among individuals and these differences matter. This variable strongly influences the search for and the decision to exploit an opportunity and it also influences the relative success of the exploitation process."(:123) Two people with the same knowledge may put it to very different uses. "The incentive, capability and specific behaviours needed to profit from useful knowledge or insights all vary among individuals, and these differences matter for explaining the exercise of enterprise." (:124)	E
Shane (2000)	"Entrepreneurs discover opportunities related to the information that they already possess." (:448) Shane proposes: • people's prior knowledge about markets will influence their discovery of which markets to enter to exploit a new technology; • people's prior knowledge about how to serve markets will influence their discovery of how to use a new technology to serve a market; • people's prior knowledge of customer problems will influence their discovery of products and services to exploit a new technology. (:452) "The prior distribution of knowledge in society influences who discovers entrepreneurial opportunities." (:465) "Technological change does not generate obvious entrepreneurial opportunities." (:465)	E
Shane (2003)	"Prior knowledge provides an absorptive capacity (Cohen & Levinthal, 1990) that facilitates the acquisition of additional information about markets, technologies and production processes which in turn, enhances the ability to formulate new means-ends frameworks." (Shane 2003:13)	E
Shane and Venkataraman (2000)	"Technological, political, social regulatory and other types of change offer a continuous supply of new information about ways to use resources to enhance wealth…..New information alters the value of resources and , therefore, the proper equilibrium price…. because information is imperfectly distributed, all economic actors do not receive new information at the same time." (:221)	E
Aldrich & Martinez (2001)	"Many entrepreneurs differ in the way they apply and evaluate their knowledge and capabilities."(:46), "Constraints to entrepreneurial activity – rapid knowledge acquisition under conditions of uncertainty" "In innovative businesses, there may be no organizations to imitate. Knowledge about success strategies can be limited. This is even more acute for real innovators." (:49), "Entrepreneurs have the potential of learning during the process of constructing their firms." (:52)	E
Literature fields: E: Enterpreneurship, CE: Corporate entrepreneurship, Org L: Organisational learning, RBV: Resource-based view of the firm, KBV: Knowledge-based view of the firm.		

Table continued on next page

Table 2.2 A literature review of the role of knowledge in entrepreneurship (continued)

Author	The role of knowledge	Field
Ucbasaran, Westhead & Wright (2001)	"Entrepreneurs often have to make decision with little or no historical trends, no previous levels of performance, and little if any market information surrounding whether new products and services will be accepted."(:59) "Entrepreneurs gain new insights from interpreting new combinations of information via heuristic-based logic." (:59) "Entrepreneurial learning goes beyond acquiring new information by connecting and making inferences from various pieces of information that have not previously been connected." (:62)	E
Zahra & Filatochev (2004)	"The threshold companies' stock of knowledge and competencies is often lopsided because it embodies a few technological bases that are targeted to a chosen niche. This lop-sidedness might limit entrepreneurial firms' ability to import, assimilate and use knowledge from external sources."(:887) "A limited and specialised technological base may constrain these firms' search zone, reducing their ability to obtain and use the knowledge developed elsewhere. The board of directors can play an important role in prompting the firm to seek diverse knowledge and expand its absorptive capacity."(:889) "The ability to change is underpinned by manager's knowledge and learning capacity that directly affects the quality and timing of their strategic decisions." (:889)	CE
Zahra, Neilsen & Bogner (1999)	1. CE efforts are important for successful organizational learning and knowledge creation; 2. Creating value from the wide range of new knowledge generated in CE activities requires management of the process of articulating, focusing sharing and transferring this knowledge. These processes are essentially for the development and maintenance of competence. The knowledge processes captured by CE activities are multifaceted and complex. Through knowledge articulation and transfer, a foundation for building organizational competence is set; 3. Trust is important for utilizing knowledge; 4.Organizational culture can profoundly influence the interpretation and subsequent uses of merging knowledge. (:185)	CE
Ireland, Covin & Kuratko (2009)	"Just as individual managers can acquire knowledge and skills through their entrepreneurial behaviours, organizations can learn and develop capabilities by implementing CE strategies."(:34)	CE
Dess et al. (2003)	"Learning means the acquisition of information and knowledge that is new for a firm. This learning is important for the creation and exploitation of the knowledge necessary for the product, process and organizational innovation." (:352)	CE
Kuratko et al.(2001)	Knowledge can be created through effective CE.	CE
Ireland et al.(2001)	Firms benefit by facilitating the development and management of knowledge stocks and flows between people and organisational units.	CE
Kazanjian et al. (2001)	Propose three knowledge management tasks central to CE which all involve extending knowledge in some way: leveraging existing knowledge bases, recombining and extending existing knowledge bases; and importing or acquiring new knowledge bases. (2001:179) "A detailed understanding of the existing resource and knowledge base of the firm is necessary to frame the knowledge management process associated with innovation and corporate entrepreneurship." (:192) "Strategies for corporate entrepreneurship that target related domains must exploit existing knowledge, while strategies that target less-related domains must develop knowledge competencies beyond those associated with current products and markets."(:192) "New knowledge created through the process of corporate entrepreneurship returns to existing stocks, increasing and changing a firm's absorptive capacity (Cohen & Levinthal, 1990) and effecting organizational value creation." (:193)	KBV of CE
Dutta & Crossan (2005)	Supports the multi-level and interconnectedness nature of the entrepreneurial process Describe the multilevel phenomena of opportunity recognition and exploitation as follows [Four I framework]: "… learning begins when individuals develop an intuition [the first I] with respect to a business opportunity on the basis of their prior experience and recognition of patterns as external events unfold. The individuals use these patterns to make sense of what is going on – to interpret an insight or an idea and to put it into words. Individual interpretation [the second I] can be strengthened or reinforced by sharing it with a group who can then engage on joint exploration, interpretation, and integration [the third I] of the idea, to develop it into a shared understanding of feasible business proposition. Over time, shared understanding can be institutionalized [the fourth I] at the organizational level in the form of systems, structure, strategy and procedures." (:434 – 5)	Org L & E
Vesper (1996)	Three of the most likely sources of entrepreneurial knowledge are previous work experience, advice from experts, and imitating and copying.	Org L
Sitkin (1992)	Short time windows between conception of ideas and execution allow little time for contemplation of ideas, and therefore provides more opportunities for learning.	Org L
Lumpkin & Lichtenstein(2005)	Organizational learning can enhance a firm's ability to recognize opportunities and equip them to effectively pursue new ventures. (:452)	Org L
Literature fields: E: Entrepreneurship, CE: Corporate entrepreneurship, Org L: Organisational learning, RBV: Resource based view of the firm, KBV: Knowledge based view of the firm.		

Source: developed by the researcher from a review of entrepreneurship literature

of gaining knowledge that stimulates innovation and increases the firm's absorptive capacity. Colombo and Grilli (2005) suggest that successful exploitation of a new business opportunity generally requires the integration of complementary context specific knowledge (e.g., knowledge relating to complementary technological fields, technological marketing and managerial knowledge) that is dispersed among individuals. Therefore, creating a functionally-balanced founding team composed of individuals with heterogeneous but complementary capabilities will lead to better post-entry performances (Cooper & Bruno, 1977; Ensley et al., 1998; Eisenhardt & Schoonhoven, 1990).

With respect to organisational responsiveness, Liao, Welsh and Stoica (2003:67) state that the viability of a firm's knowledge chain determines its ability to overcome the forces of inertia to react swiftly and decisively to environmental changes. "The knowledge chain represents a company's cognitive power for action, which is its capacity for recognising, anticipating, and acting on market shifts and movements, or new technological developments in a way that is superior to its competitors". Agility, resourcefulness and an ability to learn from mistakes signify superior competitors (Nonaka, 1994; Van den Bosch, Volberda, & de Boer, 1999). It is not only the quality and quantity of information and knowledge that companies acquire and assimilate, that differentiates superior companies, but the speed at which they can move through the knowledge cycle (McKenna, 1995).

2.6 Innovation as a driver of firm growth

2.6.1 What is innovation?

Innovation is defined by Drucker (1998:3) as a specific function of entrepreneurship. "It is the means by which the entrepreneur either creates new wealth-producing resources or endows existing resources with enhanced potential for creating wealth." Innovative activity, which can be initiated by individuals or organisations, reflects a firm's entrepreneurial orientation (Lumpkin & Dess, 1996). Innovation has long been seen as an integral part of entrepreneurship (Covin & Miles, 1999; Drucker, 1985; Schumpeter, 1934, 1942), as highlighted in the previous section. Innovation is perceived by entrepreneurship researchers to be the way through which opportunities are exploited (e.g. Shane & Venkataraman, 2000) and as the primary instrument of competition for many firms (Baumol, 2002).

2.6.2 Types of innovation

Schumpeter (1934) identified 5 types of innovation (table 2.5) that contribute to the entrepreneurship of the firm, highlighting entrepreneurial innovation as the driving force behind organisational change and central to capitalism. Schumpeter also emphasises major

Table 2.3 Schumpeter's five types of innovation

1. The introduction of a *new good* – that is, one with which consumers are not yet familiar – or of a new quality of a good.
2. The introduction of a *new method of production*, that is one not yet tested by experience in the branch of manufacture concerned, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially.
3. The opening of a *new market*, that is, a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before.
4. The conquest of a *new source of supply* of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created.
5. The carrying out of the *new organization* of any industry, like the creation of a monopoly position (for example through trustification) or the breaking up of a monopoly position.

Source: Schumpeter (1934:66)

innovations that require the creation of new knowledge (table 2.3). The combination of product, process and organisational innovations allow the firm to compete vigorously, renew its operations, and create new revenue streams (Kanter, 1986). The majority of the innovation literature has focused on the impact of technological innovation on product development in high technology sectors. For example, Kuemmerle (2006:313) defines innovation as "the process of converting technological advances or inventions into new products or product attributes with the goal of creating demand and increasing market share". Zahra et al. (2000) on the other hand advocate taking a comprehensive view of innovation as a key dimension of entrepreneurship, with attention paid to product process and organisational innovation.

Radical versus incremental innovation

Following on from Schumpeter's emphasis on major innovations, the literature has characterised different types of innovation according to their impact on the capabilities of the firm (Henderson & Clark, 1990) Many scholars have documented the interplay between major (also described as radical or discontinuous innovation) and incremental innovation (Mueller & Tilton, 1969; Abernathy, 1978; Nelson & Winter, 1982; Tushman & Anderson, 1986; Pavitt, 1991).

Incremental innovation introduces relatively minor changes to existing products, in doing so exploits the potential of established design and is argued to reinforce the dominance of established firms (Nelson & Winter, 1982; Ettlie, Bridges & O'Keefe, 1984; Dewar & Dutton, 1986; Tushman & Anderson, 1986; Pavitt, 1991). In the early stages of a technology's history, before the emergence of a dominant design, organisations competing to design successful products must experiment with a number of alternative technologies. Periods of experimentation are brought to an end by the emergence of a dominant design (Abernathy & Utterback, 1978). Even in fast-moving dynamic industries such as life sciences, once a product or process has been established, it will be improved upon through a series of incremental innovations and will only be re-evaluated if a new radical innovation displaces it.

In contrast, radical innovation is more dramatic as it can transform existing markets, create new ones and make enormous economic contribution (Leifer et al., 2000). Radical

innovation is based on different engineering and scientific principles and often opens up whole new markets and potential applications (Dess & Beard, 1984; Ettlie, Bridges & O'Keefe, 1984; Dewar & Dutton, 1986). Radical innovation lies at the core of new business development and long-term wealth creation (Ahuja & Lampert, 2001; Kirchhoff, 1991). For a small high-tech firm, radical innovations can have enormous potential benefits, but without the resources to create a new market, it can be difficult to commercially exploit. Radical and incremental innovations require different organisational competencies, and organisational capabilities are difficult to create and costly to adjust (Nelson & Winter 1982; Hannah & Freeman, 1984).

2.6.3 How does innovation drive firm growth?

Many theoretical and descriptive accounts of firm growth stress the important role of innovation (Coad & Rao, 2008). Scholars regard innovation as a strategic choice (e.g., Thornhill, 2006:689), firm-level behaviour that enables the firm to deploy its assets (Amit & Shoemaker, 1983) and resources for superior performance. Innovation is also linked to performance and growth of the firm through improvements in efficiency, productivity, quality, and competitive positioning. Economic theorising also recognises the centrality of innovation in the growth of firm sales (e.g., Geroski, 2000); however empirical studies have had difficulty in identifying any strong link between innovation and sales growth. Coad and Rao (2008:635), having taken a quantile regression approach, conclude that innovation is of crucial importance for a handful of 'superstar' growth firms or gazelles (Birch, 1984). However, they observe that firms in turbulent, highly innovative sectors can never be certain how they will perform in the future. Coad & Rao (2008:646) note that "Innovative firms may succeed spectacularly or (if they do not discover a commercially valuable innovation), they may waste a large amount of resources while their market share is threatened by more successful rivals."

The main driver leading firms to exploit new technical knowledge for use in their products and services is competitive pressure from other firms (Pavitt & Steinmueller, 2002). Porter (1980) advocated a technological product leadership strategy as a differentiation strategy, which emphasises R&D and the development and application of new technologies. This echoes the view of Roberts (1999) who suggest that a firm that repeatedly introduces

innovation will demonstrate sustained profitability. Lieberman & Montgomery (1988) and Bantel (1997) advocate the growth benefits of technological leadership, stimulation of market demand and rapid market growth gained from 'first mover' advantage, but this growth strategy depends on rapid exploitation of knowledge. Failure to develop new technical knowledge may render products and services uncompetitive and make firms vulnerable to the process of creative destruction (Schumpeter, 1942). An empirical study by Harris & Li (2009) suggests that the competitive advantages that the firm creates, through innovative behaviour (R&D investments, product and process innovations), increases the likelihood of internationalisation and growth of the firm.

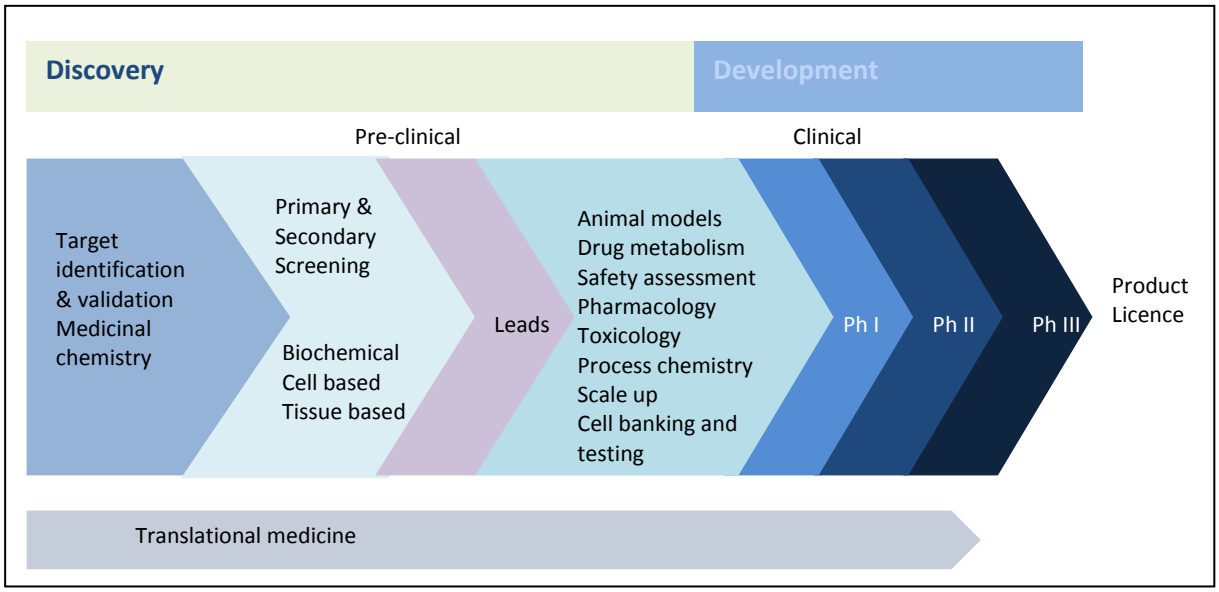
Competitive pressures are different in different industries (Pavitt & Steinmueller, 2002), but are more of an issue in the dynamic high technology environment (Eisenhardt & Martin, 2000), such as the life science industry where due to the progress of science, there is constant pressure to keep up with the latest developments. Ernst and Young (2009) argue that the life science industry, perhaps more than any other sector, depends on technological innovation for their very survival. Biotechnology represents a competence destroying radical innovation because it builds on a scientific basis (immunology and molecular biology) that differs from the knowledge base (organic chemistry) of the more established pharmaceutical industry. However, the potential new protein drugs made possible by biotechnology must all go through the same clinical tests and regulatory approval and are sold through the same distribution channels as traditional drugs. Therefore there is still significant opportunity for established pharmaceutical companies with existing organisational capabilities in the downstream functions to bring these new drugs to market (Pisano, 1990).

Palmberg (2004:184) argues that a key insight from this literature is that levels of technological opportunity (Nelson & Winter, 1977) vary significantly across industries and sectors, depending on the vitality of the underlying science, and the technological fields that firms draw upon during innovation. Technological opportunities determine the productivity of R&D, and therefore are the incentive for firms to engage in R&D.

The effect on firm growth of any one activity such as innovation in isolation is difficult to measure, because it involves many activities out-with R&D, such as acquisition of

equipment, industrial design, marketing and training, many of which do not appear on the firm's balance sheet. Coad and Rao (2008:634) argue that the major difficulty in observing the effect of innovation on growth is that it may take a long time to translate increases in economically valuable knowledge (innovation) into economic performance. In order for innovation to lead to growth, it must be successfully commercially exploited. Due to the long complex value chains in high-tech industries such as life sciences, the full value of an innovation is often realised by partners significantly downstream in the value chain.

Figure 2.5 Innovation in the pharmaceutical industry – the drug development pipeline



Source: Developed by the researcher

Typically, it involves significant investment in product development to convert a product idea into a product that can be commercialised, and the innovation process suffers high levels of uncertainty at every stage of the process. For example, in the pharmaceutical industry fewer than 1 in 10 drugs that go into clinical trials obtain approval by the regulatory authorities for use as a therapeutic drug for humans. The typical innovation development process in the pharmaceutical industry (see Figure 2.5) takes in excess of 12 years. There are considerable lags between the time of the discovery of a valuable innovation and its conversion into a commercial success. The clinical R&D costs for a therapeutic drug are estimated to be in the region of $800m - $1billion, and rely on the global marketing of successful 'blockbusters' to recoup development costs. The industry relies on partnerships and collaborations up and down the value chain, with large

pharmaceutical companies increasingly being more involved in downstream clinical development and marketing activities.

2.6.4 The role of knowledge in innovation

Knowledge plays a vital role in the search for innovation and many theoretical and empirical studies in economics have demonstrated the importance of knowledge and experience in enabling firms to successfully implement and adapt changes in technology (Bartel & Lichtenberg, 1987, 1990; Siegel, Waldman & Youngdahl, 1997; Siegel, 1999). This supports the RBV and KBV of the firm, which are unequivocal about the role of knowledge in creating competitive advantage (Barney, 1991; Kogut & Zander, 1996; Spender, 1996a). In the fast pace of technological and scientifically based innovation in high-technology firms, knowledge utilisation needs to be as intentional, methodical and effective as the utilisation of any other resources (Drucker, 1993). This is echoed by Calantone et al. (2002), who argue that since the innovation process involves the acquisition, dissemination and use of new knowledge, a learning orientation is an important antecedent of firm innovativeness, and in turn, firm performance. These arguments together suggest that knowledge and its leverage play a key role in all other factors that impact on firm growth, and so cannot be seen independently.

In large multinational firms, many studies have observed that these firms actively develop technological knowledge within a number of separate fields. (Kodama, 1986; Pavitt et al., 1989; Grandstand & Sjölander, 1990; Oskarsson, 1993; Grandstrand, 1998; Patel & Pavitt, 1998). These authors argue that the increase in technological fields is due to the progress in science and technology and the increasingly interdisciplinary nature of science. In order to sustain a competitive position within their product/service marketplace, firms need to be able to respond to competitive pressures of new technological opportunities while integrating new technologies with existing ones. Although this is possible in large pharmaceutical companies, SMEs in the life science industry struggle to deal with the costs associated with this. For HTNVs, the technical knowledge available to the firms' entrepreneurs will increase during growth, making it possible to identify further opportunities for growth (Saemundsson, 2005).

The ability to identify new productive opportunities is dependent on the knowledge of the firm's entrepreneurs and the staff they employ as the firm grows. Christensen and Petersen (1990) conducted one of the earliest studies of knowledge and opportunity recognition and stressed the importance of both technology and market knowledge as prerequisites to recognising opportunities. Numerous other studies from the new product development literature emphasise the role of specific and divergent knowledge types in recognising and developing opportunities (e.g., Iansiti, 1993; Leonard & Sensiper, 1998; O'Connor & Veryzer, 2001). Palmberg (2004) argues that a firm has to assimilate more than just the scientific knowledge for the successful commercialisation of an innovation. Palmer's research in Finnish firms demonstrated that customer demand, market niches, collaboration with customers, environmental issues, regulations and standards were just as important sources of innovation. Echoing Penrose's (1959) view of limited resources, Saemundsson (2005:224) argues that while diversification may make firms less vulnerable to abrupt changes in their environments, it puts a strain on the firms' resources, especially in competitive and technologically progressive environments. This restricts the number of fields that a firm can support at any given time (Penrose, 1959:104–152).

2.6.5 Sources of knowledge for innovation

While in-house R&D has traditionally been seen as an important source of technical know-how for firms (Mowery, 1983), it is not the only possible source (Pisano, 1990). Reflecting on three models of innovation can shed light on the sources of knowledge for innovation (Tether & Tajar, 2008). In the traditional *'closed model' of innovation*, which Chesbrough (2003) states is based on a philosophy of self-reliance, the firm generates, develops, and commercialises its own ideas. This model is not an option for SMEs, which are often resource constrained. This has been the model that pharmaceutical firms favoured but even in this model, firms were known to access knowledge from universities and the public science base. The firm's investment in the public science base through collaborations allows it to access new technology and maintain its absorptive capacity (Cohen & Levinthal, 1989, 1990). Rosenberg (1990) argues that firms conduct basic research for 5 reasons: 1) there are often first mover advantages that more than offset any disadvantages. In addition, a basic research capability is essential for 2) understanding better how and where to conduct applied research, 3) evaluating the outcome of applied

research and understanding its applications, 4) monitoring and evaluating research being conducted elsewhere, and 5) remaining effectively plugged into scientific networks.

In the *'external model' of innovation*, fully fledged innovations are developed externally and then implemented or commercialised by the firm. In this model, externally sourced innovation substitutes for internal R&D. R&D outsourcing is increasing (Howells, 1999; Foley, 2000), but complete reliance on this model of innovation is still unusual because innovation is dependent on contextual knowledge from markets, supply chains and firm specific factors for its full development and exploitation (von Hippel, 1998). Various empirical studies have documented the differences in the degree to which firms obtain R&D services from in-house versus external sources (e.g., von Hippel, 1982; Pavitt, 1986) In the case of the life science industry, biotechnology companies can be a source of innovation for pharmaceutical companies who wish to follow this model.

Chesbrough (2003) argues that the *'open model' of innovation*, involves both actively seeking and appraising external ideas, while also commercialising its own R&D. This is consistent with the concept of 'external orientation' developed by Tidd et al. (2005:500-501). Tether and Tajar (2008) suggest that social capital is important to firms following an open innovation model, enabling the firm to both seek out and forge effective relationships with appropriate partners. Partnerships, strategic alliances, outsourcing and maintaining a virtual model are all ways in which small firms in this high technology environment deal with the need to incorporate diverse technologies in order to commercialise an innovation successfully. West (2003) points to a trade-off between adoption and value appropriation in considering open innovation.

2.6.6 The importance of external knowledge for innovation

Despite its importance, firms often lack the knowledge they need and are forced to either develop it internally or source it externally. Liebeskind et al. (1996) note that due to the complexity, time and resources required to develop knowledge internally, external sourcing of knowledge is an attractive and frequently used alternative, especially in fast-paced industries. Crucial knowledge often lies beyond firm boundaries, requiring firms to tap into external knowledge to develop and maintain their competitive advantage (Dierickx

& Cool, 1989; Powell et al., 1996; Al-Laham & Amburgey, 2005). The ability to exploit external knowledge is a critical component of innovative capabilities.

Innovation is cumulative, and accumulated knowledge provides a guide to the search process for new knowledge (Helfat, 1994). Firms tend to search for new technical knowledge in areas that enable them to build upon their established knowledge and resource base (Nelson & Winter, 1982). Cohen and Levinthal (1989, 1990) were among the first to highlight the role of R&D in developing the firm's ability to identify, assimilate and exploit knowledge from the environment – a firm's absorptive capacity (literature on the absorptive capacity construct is reviewed in Chapter 3). This makes the technological profile of firms stable over time and differentiated from most other firms, apart from those in the same industry (Patel & Pavitt, 1998). One important external source of knowledge relevant for innovation, especially in high-technology industries, is university-generated research (Fabrizio, 2009). Cockburn and Henderson (1998) summarise case studies of many important drug developments, stating that firms rely on basic science for developments in biology and biochemistry and many new drugs and delivery systems have their origins in discoveries at universities or government laboratories. This view is echoed by many researchers who have described industry use of university based basic scientific research in the development of new products and processes (Coombs & Deeds, 2000).

External knowledge sourcing is an important strategic activity, given the levels of innovation and R&D required in all sectors, particularly in knowledge-intensive industries (Carayannopoulos & Auster, 2010). Some scholars suggest that knowledge sourcing is a more critical organisational activity than the exploitation of currently held knowledge in dynamic environments characterised by rapid technological change (Madhok, 2007). Most innovation occurs at the boundaries between specialised domains (Leonard-Barton, 1995). Carlile (2004) re-emphasises this point, suggesting that effectively managing knowledge across various types of boundaries in an organisation is what drives competitive advantage. He advocates that rather than seeing firms as bundles of resources, as in the RBV (Barney, 1991), they can be better described as a bundle of boundaries where knowledge should be shared and accessed.

The pervasiveness of networking has become a significant feature in current innovation management practice (Veugelers, 1997). Firms can tap into the R&D capabilities of competitors and suppliers, license technology, or enter into R&D collaboration agreements and joint ventures. "Informal" know-how trading is the extensive exchange of proprietary know-how by informal networks of process engineers in rival (and non-rival) firms (von Hippel, 1987). International research networks are also important, as they contain specialist academic research groups and companies, which act as loci of innovation upon which companies can draw to feed their product pipelines. The capability of managing a network is essential in order for a firm to be able to gain advantage from such collaborations.

2. 7 Internationalisation as a driver of firm growth

Growth by international diversification is an important strategic option for firms of all sizes (Lu & Beamish, 2001), and in particular for firms whose business scope is geographically confined (Barringer & Greening, 1998). The traditional view of internationalisation was based on large firms expanding into new geographies gradually to take advantage of new customer bases and the cost advantage of economies of scale. Early small firm growth and HTNV literature virtually ignores internationalisation as a key factor in the growth process (Reuber & Fischer, 2002). However, more recent studies have shown that "internationalization is part of, and inseparable from the overall growth and development process of small firms" Jones (1999:15). Given that HTNVs operate in knowledge-intensive industries that are global in their nature, and the growth process, is embedded in context, as all processes are, this study considers internationalisation as a factor for growth. This section emphasises that internationalisation is essential for the commercial exploitation of knowledge, and a key driver of growth, in a global industry such as life sciences. Furthermore, it highlights the leverage of external knowledge as a key facilitator for the development of competitive advantage and growth of SMEs in that international environment.

2.7.1 A trend of early and rapid internationalisation of HTNVs

Expanding into new geographical markets provides SMEs with an important opportunity for growth and value creation. Lu and Beamish (2001) predict that early internationalisation of SMEs will gain further momentum as the world becomes increasingly integrated, as new technology makes communication easier (Petersen & Welch, 2003) and government imposed barriers reduce. In particular, knowledge intensive HTNVs are less constrained by national boundaries and can therefore exploit international opportunities more flexibly than firms dependent on fixed assets alone (Autio et al.,2000). Many HTNVs, with significant R&D costs which they cannot recover in their domestic markets or in any single overseas market, face significant pressure to internationalise across multiple markets quickly to optimise return on investment. Furthermore, for many HTNVs, the competitive advantage around which these firms are founded is related to a technological niche for which demand is confined to a relatively small number of clients in multiple geographical regions (Oakey, 1995). Therefore, HTMVs often have no choice but to operate internationally from the outset (Keeble et al., 1998).

Global niche markets are characterised by technical product standards being defined globally and independently of national environments (Morgan-Thomas & Jones, 2009). The increasing homogenisation of buyer preferences, which assists international business by simplifying product development and positioning across multiple foreign markets (e.g., Knight & Cavusgil, 2007). This homogeneity of products and services is also the case in the life science industry. In high-technology industries, this is also assisted by the fact that the development of science is an international pursuit and does not happen in isolation in one particular geographical market. As technological advances are made they are adopted and become standards for all players at the leading edge of each highly specialised technical field. The presence of competitors or potential competitors operating globally is a motivating force which encourages firms to take pre-emptive advantage of technological opportunities in multiple foreign markets while the firm can establish their product as the standard (Oviatt & McDougall, 2005). The need to achieve rapid sales internationally can also drive the firm to use agents and distributors in some overseas markets (Jones & Crick, 2004).

2.7.2 Early internationalisation - a driver of firm growth

Internationally active SMEs tend to be more dynamic and grow faster than strictly domestic firms (Rennie, 1993; Bell, 1995). Since the 1990s, there has been significant research into the internationalisation of small firms. By leveraging resources in different markets, firms are able to capitalise on market imperfections and achieve higher returns on their resources. Barringer & Greening (1998) argue that international growth is a particularly important growth strategy for SMEs whose business scope has been geographically constrained. In pursuit of growth, SMEs will adopt a geographical expansion strategy to pursue new opportunities to leverage core competencies across a broader range of markets (Zahra, Ireland and Hitt, 2000), accessing additional customer bases, achieving larger volumes of production and sales, and firm growth (Lu & Beamish, 2001).

The establishment of a direct relationship between the internationalisation and the performance and growth of small firms has been notably absent from the majority of the previous research and little is known about the effects of internationalisation on performance (Covin & Slevin, 1991; McDougall & Oviatt, 1996; Coviello & McAuley, 1999; Reuber & Fischer, 2002). The relationship between growth and survival is neither linear nor simple. For example, empirical results regarding early internationalisation and performance have been mixed (Bloodgood, Sapienza, & Almeida, 1996; Zahra & George, 2002a). Delmar, Davidsson and Gartner (2003) note that although growth enhances survival, it is not always guaranteed. Some studies (e.g., Eriksson et al., 1997; Sapienza et al., 2006) suggest that the later initiation of the internationalisation process can provide greater chances of organisational survival. Sapienza et al. (2006) suggest that early internationalisation may decrease the probability of survival but simultaneously increase prospects for growth. This is in contrast to the dynamics capability view that typically assumes that capability development has only positive effects on firm performance. Sapienza et al. (2006:915) argue that "initiation of internationalization activities (which eventually create new capabilities) is an investment-intensive process that saps a firm's resources and thus may reduce the chances of firm survival in the short-term." Firms have to survive first and foremost in order to experience future growth. Lu and Beamish (2001:582) found that in the early stages of internationalisation, performance declines as

the firm deals with the liability of foreignness. Performance then improves as new knowledge capabilities are developed and as competitiveness is enhanced and market opportunities can be fully capitalised upon. It is thought that SMEs, with limited resources and capabilities, are more susceptible to the liability of foreignness than large firms. Furthermore, the higher levels of risk an SME faces when entering a foreign market, relative to domestic expansion, reinforces the entrepreneurial characteristic of the internationalisation strategy.

Autio et al. (2000) posit that early internationalisers are likely to grow more rapidly than older entrants due to the 'learning advantages of newness', despite the liabilities of newness. This is in contrast to firms that begin operations with a strong domestic focus, which may have to unlearn certain practices that are not applicable to international activity. Embedded practices within the firm can be the cause of difficulties in internationalisation (Knight et al., 2004) due to the lack of flexibility and adaptability within the firm. The later a firm internationalises, the more likely that it will possess entrenched routines, which may restrict the search processes for new opportunities (Gavetti & Levinthal, 2000). Entrepreneurship researchers have regarded the entering of new geographical markets as an act of entrepreneurship that proactively capitalises on an opportunity (e.g., Lumpkin & Dess, 1996; Barringer & Greening, 1998; Zahra, Kuratko & Jennings, 1999). Capabilities gained by virtue of early internationalisation gives the new venture learning advantages that increase the probability of growth (Autio, Sapienza & Almeida, 2000). Although internationalization is thought to initially decrease the prospects for firm survival, it exposes the firm to opportunities to grow and to learn how to grow, drawing on the dynamic capability theory, Sapienza et al. (2006:920) argue that "internationalization influences the development of capabilities that give the organisation the flexibility to pursue opportunities for growth.

2.7.3 Models of internationalisation and the role of knowledge

It is undisputed that new knowledge and capabilities need to be acquired or developed to enter new markets successfully (e.g., Andersen, 1993; Barkema & Vermeulen, 1998; Inkpen & Beamish, 1997; Lord & Ranft, 2000; Zahra et al., 2000), and that the source of this additional knowledge is likely to be external to the firm. There are many well-

established models of internationalisation of large multinational enterprises that originate from the 1970s; for example product life cycle (Vernon, 1966), transaction cost (Williamson, 1975), market imperfections (Hymer, 1976), and the eclectic paradigm (Dunning, 1977). More recently, as described in the previous section, there is evidence that small firms are increasingly active in international markets. Two main frameworks have dominated the study of internationalisation of small firms: the *process theories of internationalisation* (Johanson & Wiedersheim-Paul, 1975; Johanson & Valne, 1977, 1990; Bilkey & Tesar, 1977; Cavusgil, 1980) and the *new venture internationalisation* (Oviatt & McDougall, 1994; McDougall et al., 1994). The theoretical dimensions of these theories is summarised by Autio (2005:17). Knowledge is considered to be a critical determinant of international expansion in both the process theory and new venture theory of internationalisation (Sapienza et al., 2006), but with a different emphasis on the role of knowledge. These are explored in turn, along with the more recent *network approach to internationalisation*, in the following pages.

- *Process models of internationalisation and knowledge*

Two similar process models of internationalisation were developed in the 1970s: the Uppsala or U-model (Johanson & Wiedersheim-Paul, 1975; Johanson & Vahlne, 1977) in Europe and the Innovation-related or I-model (Bilkey & Tesar, 1977; Cavusgil, 1980, Reid, 1981; Czinkota, 1982) developed in the US. Both models view internationalisation as a gradual process with a number of stages. Johanson & Vahlne (1977) concluded that firms enter new markets with successively greater psychic distance in a series of stages. The concept psychic distance, has been defined as 'factors preventing the flow of information from and to the markets' and include factors such as language, culture, political systems, level of education and level of industrial development (Johanson & Vahlne, 1977:24). The role of psychic distance is also central to each of the I-models (Brennan & Garvey, 2009).

International process theory (IPT) puts experiential foreign market knowledge at the centre of the internationalisation process (Johanson & Vahlne, 1977,1990), and in doing so, has contributed greatly to the understanding of international growth processes of firms (Brennan & Garvey, 2009). A key assumption of the process theories is that firms initiate

their foreign activities with no foreign market or foreign organising knowledge and that this knowledge can only be acquired through operating in foreign markets (Johanson & Vahlne, 1977) in a learning-by-doing process. Market entry gives the firm first-hand knowledge of the market, and connections with competitors, suppliers and innovation centres outside its domestic market (Birkinshaw, 2000). Therefore, experience of foreign market entry impact the performance of the internationalising firm. The U-model contains different steps that describe the firm's level of internationalisation. Market-specific experiential knowledge input is seen to be the driving force that reduces risk and encourages the firm to commit the resources required to move the next level of internationalisation. In the I-model, internationalisation is represented as an innovation of the firm, drawing on the entrepreneurship literature. Andersen (1993) depicts both the U- and I-models as being behaviourally oriented and lacking experiential knowledge, and uncertainty relating to decisions, causes the gradual pattern of internationalisation. SMEs can acquire host country knowledge and develop new organisational capabilities internally through incremental experience accumulated in new geographical regions (Johansson & Vahlne, 1977). Eriksson et al. (1997:345), acknowledging the path-dependency of learning, observe that "experiential knowledge exerts an influence on the firm's future internationalization through its influence on the search process", and therefore the future new market knowledge the firm will acquire.

The process models, although receiving strong support from a number of empirical studies in the 1980s, have been criticised by others who suggest that the choice of entry mode is dependent on the industry and country in question, and is not dependent on the firm's previous experience (Turnbull & Valla, 1986, Welch & Luostarinen, 1988). Dierickx & Cool (1989) argue that this learning by doing takes time and can result in costly mistakes that an SME cannot easily absorb (Eisenhardt & Schoonhoven, 1990). A number of researchers echo this view and argue that firms can acquire international market knowledge without direct experience in a given market by recruiting individuals who have already gained this valuable experiential market knowledge employed by other firms (e.g., Rueber & Fischer, 1997; Barkema & Vermeulen, 1998; Autio et al., 2002; Petersen et al., 2003). Johanson and Vahlne (1993) have since updated their model, as markets have become more homogenised, proposing that a firm can have considerable experience from markets that have similar characteristics and may be able to use this knowledge and experience for

new markets. This is supported by research by Eriksson et al. (1997), who concluded that experiential market knowledge was firm-specific knowledge relating to multiple markets rather than being market-specific. Peterson et al. (2003) also echo this view, suggesting that knowledge plays a more complex role than is assumed by the models developed in the 1980s.

- *International New Ventures and knowledge*

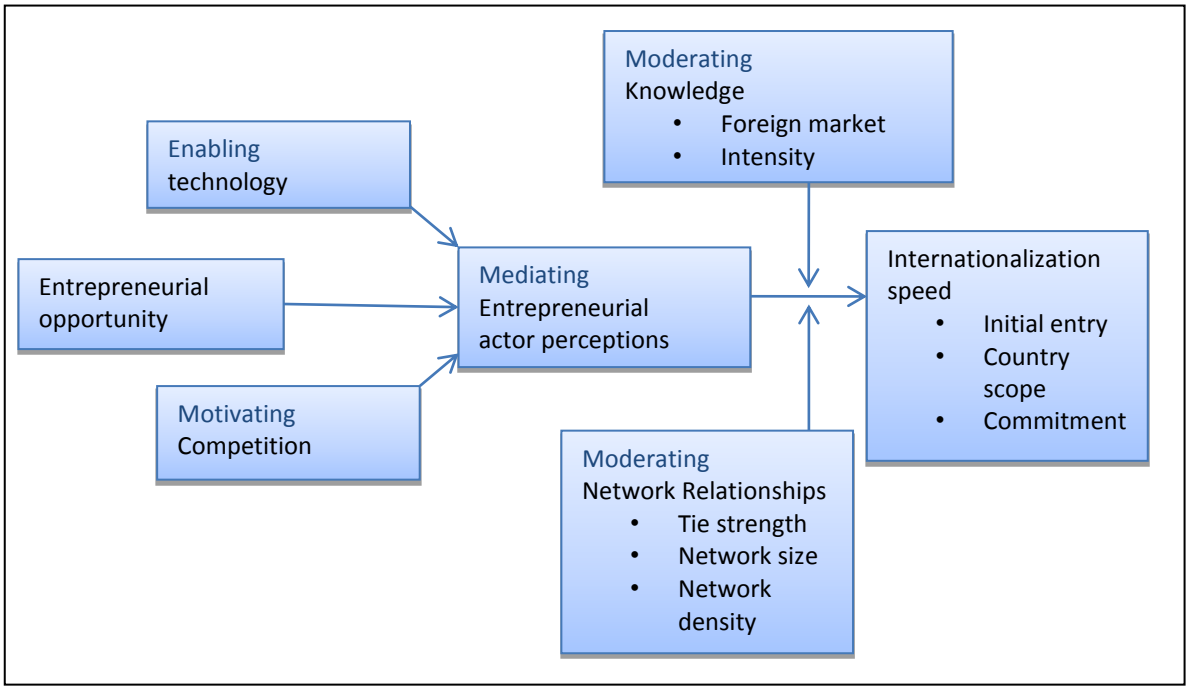
In recent decades there has been significant growth in the number of HTNVs that operate internationally from their inception or from their early years. Although other researchers have recognised the contribution of SMEs to international trade (e.g., Cannon & Willis, 1981; Douglas et al., 1982), it was Oviatt and McDougall (1994) that first highlighted the importance of smaller and younger firms, suggesting that the characteristics of international new ventures (INVs) enabled them to internationalise quickly and create value for their founders (Zahra, 2005). McDougall et al. (1994) examined the theories of international business and concluded that international entrepreneurship was not fully explained by any one theory. The INV literature sees internationalisation as an enabling mechanism for growth (Sapienza et al., 2006). McDougall et al. (1994) argue that the creation of international ventures is triggered primarily by the founders' ability to see opportunities in a cross-national context, proposing that founders develop this ability through activities earlier in their career (McDougall et al., 1994; Oviatt & McDougall, 1995), echoing much of the literature on the growth of the firm and the role of the human capital of entrepreneurs and experiential knowledge.

The original definition of international new ventures (INVs) is as follows: '*From inception, the new venture seeks to derive 'significant competitive advantage from the use of resources and sale of outputs in multiple countries'* (Oviatt & McDougall, 1994:49) Since this seminal article, the process of early internationalisation of technology-based SMEs has attracted significant attention in recent years (e.g., McDougall, 1989; Rennie, 1993; McDougall, Shane & Oviatt, 1994; Oviatt & McDougall, 1994, 1997; Coviello & Munro, 1995; Bloodgood et al., 1996; Autio et al., 1997; Knight, Madsen & Servais, 2004), resulting in the growth of fields such as INVs, born globals, and accelerated internationalisation. Brennan & Garvey (2009:127) provide a helpful synthesis of research

in the following decade until 2004. More recently, international entrepreneurship (IE) was defined as the "discovery, enactment, evaluation, and exploitation of opportunities - across national borders – to create future goods and services" (Oviatt & McDougal, 2005:540).

Drawing on the RBV and KBV, Oviatt and McDougall (1994) identified knowledge as a unique resource and one of the four necessary elements in their INV model of sustainable international new ventures (Figure 2.6). Knowledge in the entrepreneurial firm tends to be more specific to the founders and TMT[2]. Several scholars have found that firms with TMTs with previous experience in international markets have exhibited speedier entry and /or commitment to internationalisation (Almeida & Bloodgood, 1996; Bloodgood, Sapienza & Almeida 1996; Reuber & Fischer, 1997; Shrader, Oviatt & McDougall, 2000). The INV literature suggest that individual managerial and team-level knowledge and experience can substitute for firm level experience to some extent (Oviatt & McDougall, 1994). They also suggest that as international managerial experience is more widely available than in the 1970s when IPT was developed, firms can quickly acquire knowledge

Figure 2.6 A model of forces influencing internationalisation speed



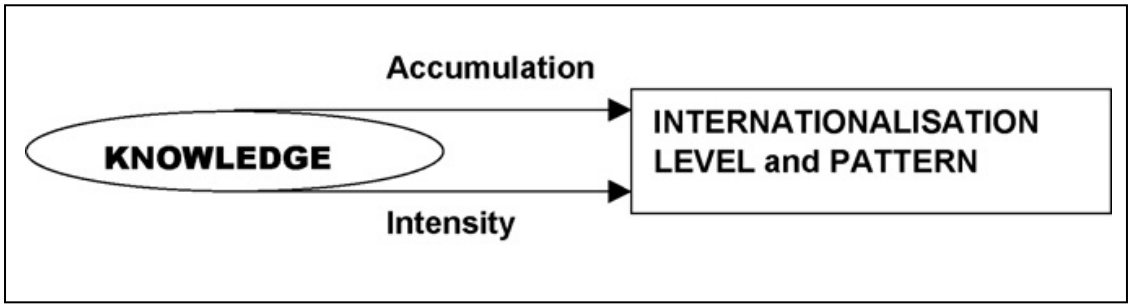
Source: Oviatt & McDougall (2005: 541)

[2] See Appendix 3 - Glossary of Terms

through recruitment. In contrast to IPT, INV literature also treats the setting up of cross-border operations as an organisational skill, which can be learned, and can constitute part of the firm's resource endowment (Autio, 2005).

Brennan and Garvey (2009), in their review of literature to date on INVs/Born Globals, note that as these new patterns of internationalisation have been researched knowledge has been found to be still central to the internationalisation process and firm growth. Scholars have also shown that INVs accumulate and transfer knowledge with greater speed than other firms (Knudsen et al., 2002). Brennan and Garvey conclude that knowledge intensity and the accumulation of knowledge within the firm drives the level and patterns of internationalisation (2009:130). Their model is reproduced in Figure 2.7.

Figure 2.7 The role of knowledge in the INV/born global phenomenon



Source: Brennan & Garvey (2009:130)

This supports the role of knowledge articulated by Oviatt and McDougall's (2005) INV model (Figure 2.6), in which knowledge intensity and network relationships are shown to have a moderating effect on internationalisation speed. Oviatt and McDougall (2005:543) argue that "after an entrepreneurial actor discovers or enacts an opportunity and interprets the enabling and the motivating forces, then the knowledge-intensity of the opportunity combined with the know-how already available to the entrepreneurial actor, plus the characteristics of the entrepreneur's international network largely determine internationalization speed". This is also consistent with Bell et al. (2003) who propose that differences in the novelty, complexity, and sophistication of the knowledge used in a firm explain the speed of internationalisation. The R&D intensity of high-technology sectors has been much cited as a key factor accelerating internationalisation (Young, 1987; Barkema & Vermeulen, 1998). Autio et al. (2000) demonstrated that the knowledge

intensity of the electronics industry requires more intensity of effort by the firm as they attempt to maximise return for new technological developments. This is echoed by Prashantham and Berry (2004) studying the computer software industry.

IE scholars argue that early-stage internationalisation reflects the exceptional awareness of highly-qualified entrepreneurs of high-return international market opportunities. In turn, this reflects the entrepreneur's particular competencies derived from experience in previous employment, technological expertise (e.g., Sapienza et al., 2006) and existing international networking links (Coviello & Munro, 1995). These internationally experienced entrepreneurs are therefore alert to new international opportunities in a way that most domestically-focused entrepreneurs are not.

- *The network approach to internationalisation and knowledge*

The network approach to internationalisation (Johanson & Mattson, 1988; Johanson & Vahlne, 1993) is an extension of the process models of internationalisation, and focuses on the role of network relationships in driving, facilitating or inhibiting the firm's internationalisation. In doing so, Johanson and Vahlne (1993:51) argued that the model should "consequently make the concepts 'commitment, knowledge, current activities and commitment decisions' as multilateral rather than unilateral as in the original model. That means that the process is also inter-organizational and not just intra-organizational". The effective use of firm networks and relationships has also been highlighted as being a key enabler of rapid internationalisation from the outset of INV theory development (Oviatt & McDougall, 1994; Coviello & Munro, 1995, 1997; Coviello, 2006). Oviatt and McDougall (1995) identified strong international business networks as one of seven most important characteristics of successful global start-ups, suggesting that networks help entrepreneurs identify international opportunities, establish credibility, and often lead to strategic alliances and other cooperative strategies. Oviatt & McDougall's (2005a:541) more recent model of factors influencing speed of internationalisation again highlights the moderating effect of network relationships (Figure 2.6).

The network approach to internationalisation draws on the social capital literature. Yli-Renko et al. (2002) found social capital to be a key regulator of learning, and of

knowledge-based competitive advantage, demonstrating a positive correlation between external social capital and the firm's foreign market knowledge. When seeking to internationalise, firms require knowledge about potential markets, buyers, sellers, products, prices and demand, and external social capital, such as contact with customers and suppliers, positively impacts on foreign market knowledge and ultimately impact of the growth of the firm. The network approach advocates that firms can obtain this internationalisation knowledge cost effectively through informal networks (Ellis, 2000; Ellis & Pecotich, 2001; Osarenkhoe, 2008). Jones (2001:193) argues that "internationalisation in today's context is less about entering foreign markets than it is about increasing the firm's exposure and response to international business influences, opportunities, threats and imperatives". This supports the view that links with individuals and organisations in the firm's external environment is likely to be a first step in internationalisation for small firms (Coviello & Munro, 1995; Coviello & Martin, 1999). Coviello (2006) states the importance of pre-foundation ties supporting Shane's (2000) view that the development of a new organisation is 'imprinted' through ties and knowledge generated pre-foundation.

INVs intentionally manage their network from the earliest stage of its cycle (Welch and Welch, 1996; Coviello, 2006). Sharma and Blostermo (2003) note the importance of the INV being central in the network. INVs have also been shown to collaborate with competitors to access knowledge resources and enhance their reputation, and this is driven by ambitious growth goals (Chetty & Wilson, 2003). This fits with Knight and Cavusgil's (2004) findings that INVs develop a range of capabilities that they leverage to achieve international goals. According to the network approach (Johanson & Mattson, 1988) internationalisation is seen as a process in which relationships are continuously established, developed, maintained and dissolved with the aim of achieving the objectives of the firm. The strategic choices made by the firm are influenced by a variety of network relationships, including the firm's choice of foreign market and entry mode (Coviello & Munro, 1997). In the same way that non-executive board members change as the company grows, networks change over time (Coviello, 2006). This supports Hite and Hesterly (2001), who argue that the entrepreneurial network will shift from being 'identity based' (path dependent) to being more 'calculative' (intentionally managed) over time. Chetty and Wilson (2003) similarly propose that initial ties are more business based if the INVs

emphasis is on managing for growth from the outset, but this theory has not been demonstrated empirically. Larson and Star (1993) similarly argue that the evolution of networks, from simple dyadic ties with previous contacts to a stage where mutuality of business interests become clear, positions the firm to leverage network ties and mobilise resources from within the network to facilitate growth.

Coviello and Munro (1995) have used network theory to examine the international market development in HTNVs. They note "Their relatively rapid and dispersed involvement in foreign markets creates the impression of being random and somewhat irrational, when in fact the span of activities can be linked to opportunities emerging from a network of relationships" Coviello and Munro (1995:58). Unplanned serendipitous ties can also be influential (Crick & Spence, 2005). This perhaps reflects the flexibility of small fast growing companies to respond to opportunities that arise from unplanned network contacts. Chetty and Blankenburgh Holm (2000) advocate that it is key that firms recognise and pursue opportunities initiated by network counterparts. Sharma and Blomstermo (2003) argue that choice of markets and entry mode are dependent on the knowledge stocks within the firm. This market knowledge comes from linkages with potential customers in the market and reduces the perceived risk of international expansion. This suggests that overseas markets are perceived to be close psychically and less risky due to linkages with the market through networks (Brennan & Garvey, 2009).

Ford (1998) found that by cooperating with partners, a firm with a focal position in a network can be influenced by knowledge from the partner's partners. A key issue for SMEs entering into an alliance for internationalisation is finding the right partner (Karagazoglu & Lindell, 1998; Baum, Calabrese & Silverman, 2000). Makino and Beamish (1998) advocate that partnership with a local partner alleviates the knowledge deficiencies of being a new entrant into a market. Lu and Beamish (2001) agree with this view, arguing that entering into alliances and having access to partners' resources is an efficient way for SMEs to overcome and alleviate local knowledge deficiencies and this has been found to be an efficient way of entering new host countries (Makino & Delios, 1996), and minimising mistakes throughout the process (Lu & Beamish, 2001). Young (1987) argues that as firms learn from the experiences of others, some of the barriers to internationalisation are reduced through the use of networks. Thus networks increase the

pace of internationalisation. This is echoed by Oviatt and McDougall (2005a:545) who suggest that if an entrepreneur already has cross-border weak direct or indirect ties (through a broker or agent), when he discovers or enacts an opportunity, the initial foreign entry may occur with unusual speed, and therefore a large entrepreneurial network is associated with faster venture internationalisation.

Although HTNVs may have a strategy of entering multiple markets from inception, due to the highly specialised nature of their product or service, it may be relatively easy to develop specialist social networks with selected key markets. This echoes the view of Jones and Crick (2004) who found that firms that concentrate on a few markets tend to gather and make use more use of information, perceive it as more useful, make more use of it and make more personal contacts as a source of market knowledge. Keeble et al. (1998) investigating HTNVs in Oxfordshire and Cambridgeshire, found that those who have achieved high levels of internationalisation were also firmly embedded in local networks and local R&D collaborations in addition to international networks. Personal networks of entrepreneurs and employees play an important role in providing information about market trends, competition and the latest technological developments (Yli-Renko et al., 2002). For some spin-outs from academia, the academic networks of founders can be limiting as they are focused on research rather than selling products or services within the market. Young (1987), however, notes that young HTNVs learn from the experience of others, and therefore networking with other local firms that are internationalising reduces the barriers to internationalisation. A recent BIS Economics paper (2010), reviewing results of recent surveys of UK businesses, also highlights that knowledge barriers to internationalisation that can be alleviated by networking.

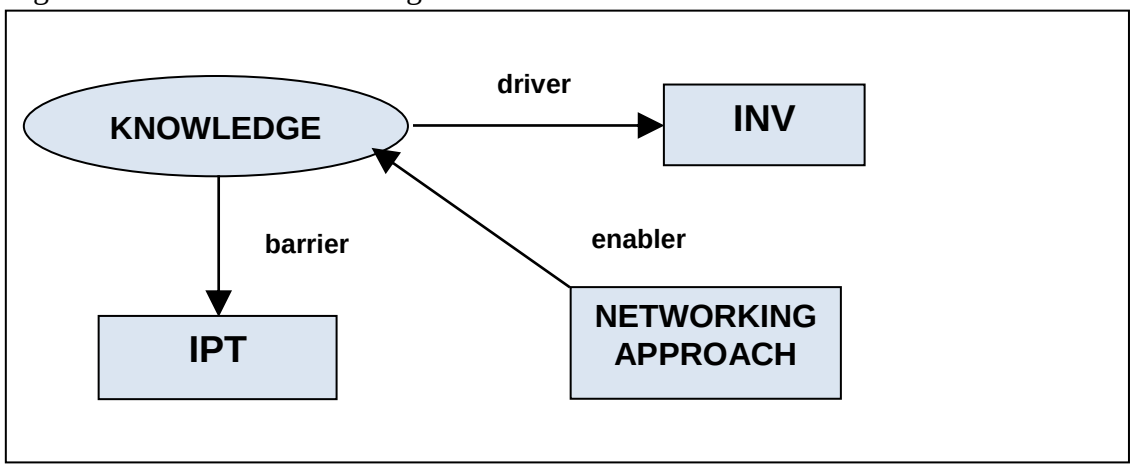
2.7.4 Summarising the role of knowledge in internationalisation

The need to acquire foreign market knowledge and the importance of organisational learning for entering or expanding in the international marketplace has been recognised by many scholars (e.g., Johanson & Vahlne, 1977; Andersen, 1993; Oviatt & McDougall, 1994; Inkpen & Beamish, 1997; Berkema & Vermeulen, 1998; Zahra et al., 2000). IPT (Johanson & Vahlne, 1977) emphasises the role of experiential knowledge, whereas INV

(Oviatt & McDougall, 1994) theory highlights knowledge intensity and technological knowledge being key to aggressive international opportunity seeking (Autio et al., 2000; Yli-Renko et al., 2002). INVs are driven by knowledge, and largely occur in knowledge-based industries, where firms achieve growth by capitalising on the creation and exploitation of knowledge (Brennan & Garvey, 2009). Yli-Renko et al. (2002:282) argue that these two views of the role of knowledge in international growth are complementary, rather than contradictory. The network approach highlights the benefits of building strategic links and alliances regardless of which internationalisation path the firm is following. The role of knowledge in the three approaches are summarised in table 2.6 and Figure 2.8.

Knowledge intensity has been identified by a number of scholars, from all three approaches to international entrepreneurship, as a key source of competitive advantage and the international growth of the firm (e.g., Autio et al., 2000; Bell et al., 2003; Coviello & McAuley, 1999; Jones, 1999; McNaughton, 2001, 2003; Yli-Renko et al., 2002). Zahra et al. (2000) also reported data demonstrating that foreign market entry is associated with a broader and deeper technological learning. McNaughton (2001, 2003) found that knowledge intensive firms served a broader scope of international markets and had a more rapid pace of internationalisation. Kuemmerle (2002) argues that the management of knowledge is particularly challenging in cross-national settings.

Figure 2.8 The role of knowledge in internationalisation



Source: adapted from Brennan & Garvey (2009:130), to include the contribution of the network approach

Table 2.4 A review of growth through internationalisation – the role of knowledge

Approaches	**Process models**		**INVs/ Born Global**	**The network approach**
	U-model	**I-model**		
Authors	Aharoni, 1966; Johanson & Wiedesheim-Paul, 1975; Johanson & Vahlne, 1977, 1990; Johanson & Mattsson, 1988; Eriksson et al.,1997; Hadjikhani, 1997	Rogers, 1962; Bilkey & Tesar, 1977; Czinkota & Johnston,1983; Cavusgil, 1980; Czinkota, 1982	McDougall, Shane & Oviatt, 1994; Oviatt & McDougall, 1994, 1995, 1997, 2005; Knight & Cavusgil 1996, 2004	Johanson & Mattsson, 1988,1992; Welch & Welch, 1996; Welch et al. 1996, , Welch, et al. 1998; Chetty & Blankenburgh Holm 2000; Coviello, 2006; Coviello & Munro, 1995,1997; Osarenkhoe, 2008, Hadley & Wilson, 2003
Size of firms	Large and small firms	All firms	SMEs	Large & SMEs
Assumptions of internationali-sation	A cumulative process of increasing international knowledge and resource commitment which is affected by incremental decisions Home base leveraging Reaction and gradual escalation Psychic distance Risk averse Asset specificity	Int. is a gradual process Internationalisation is seen as an innovative strategy in response to change in external environment Proactive approach Home base leveraging Psychic distance Risk averse Asset specificity	Globally connected industries (often high-tech & knowledge intensive) Product/service heterogeneity Entrepreneurial vision – proactive pursuit of opportunities Value creation through cross-border resource allocation Capabilities of TMT Risk taking Social capital is a facilitator Asset fungibility	Second degree internationalisation Subsidiaries' control over important resources Inward activities of importance Social capital is central
What do they say about knowledge?	Foreign market knowledge is central to the internationalisation process Market-specific experiential knowledge is of critical importance Foreign organizing knowledge is a key regulator of tangible and intangible commitments to foreign markets Lack of market knowledge is constraining – a barrier to expansion of internationalisation		Knowledge is an enabling resource Mobility of knowledge allows for more rapid internationalisation - knowledge easily deployed to a new country Highlights knowledge intensity and technical knowledge Imprinting effect – long term effect on org. Learning capabilities Knowledge is a moderating factor	Networks can be an enabler or a barrier to access market knowledge valid for firms following either PTI or INV Firms embedded in local networks – learning from others

Source: summarised by the author from the review of the literature

2.8 Additional factors influencing entrepreneurship: A summary of empirical literature on SMEs

Since the recognition of the economic contribution of small firms to the economy there has been significant empirical research into the issues that affect small firm growth. From the significant body of empirical research on new firm growth, a number of key factors have been identified as having a significant impact on the growth process of small firms. Macpherson and Holt (2007) in their review of the literature, critique much of this work as being uni-dimensional, but identify a small number of studies that take a holistic view of small firm growth (e.g., Macpherson et al., 2004; Appiah–Adu & Singh, 1998; Deakins & Freel, 1998; Keogh & Evans, 1998; Keogh, 1999; Barnett & Storey, 2000; Pena, 2002). In addition to entrepreneurship, innovation and internationalisation, these holistic studies have identified interrelated elements of human capital, organisational capital (culture, finance, structure and governance systems) and social capital as being important for small firm growth. Consistently, Coviello & McAuley (1999) in their review of empirical studies also concluded that SMEs are more likely to face resource barriers than larger firms due to their limited supply of human and financial capital.

Drawing on the resource based view of the firm (2.4.2), this section discusses these factors categorised into types of capital. However, as with many processes in the firm, they are very much embedded in context and these factors cannot be isolated from each other.

2.8.1 The role of human capital in small firm growth

Human capital comprises the stock of knowledge and skills that reside within individuals as a result of experience (Becker, 1964). Schumpeter (1934) first identified entrepreneurs as rare and important to economic development of firms. Similarly, central to Penrose's (1959) theory of the growth of the firm is the view that entrepreneurs are considered to have a particular set of capabilities to both perceive opportunities and to capitalise on them. The entrepreneurial process occurs because people act to pursue opportunities (Shane et al., 2003); therefore the human capital of individuals shape the prospects of the firms they found. As discussed in section 2.5.5, much of the research into human capital, has specifically looked at knowledge (e.g., Venkataraman, 1997; Shane, 2000; Shepherd &

de Tienne, 2005; Thorpe, MacPherson & Pittaway, 2005). Knowledge influences the entrepreneurs' ability to comprehend, extrapolate, interpret and apply new information (Roberts, 1991). It is thought that entrepreneurs will only discover opportunities directly related to their knowledge (Venkataraman, 1997). An individual's unique possession of prior knowledge creates a knowledge corridor that allows him or her to identify certain opportunities but not others (Ronstadt, 1988). BERR (2008) found that high-growth firms were likely to be founded by highly educated and experienced entrepreneurs, almost exclusively male, who started the high growth firm in their early 30s following a period of management experience. Entrepreneurs adapt their plans iteratively in response to the changing environment, provided the entrepreneur remains open to learning from experience (Gray, 2002). Creativity and flexibility is argued to be important for the exploration of new opportunities as the environment changes (Nicholls-Nixon et al., 2000; Smith & Miner, 1983). Ucbasaran, Westhead and Wright (2001, 2008) suggest that entrepreneurs who identify more opportunities are more likely to pursue better quality opportunities with greater wealth-creating potential.

Not all entrepreneurs have the same motivations for creating a venture. Differing perceptions of risk and opportunity affect the motivation of entrepreneurs (Shane & Venkataraman, 2000) and this is in turn dependent on the individual's prior experience (Shane, 2000). Storey (1994) suggested that in addition to the entrepreneurial access to resources, the entrepreneur's motivation for starting the business has an impact on firm growth; founders who start businesses for 'push' reasons are less likely to start businesses that grow than those who start because they see a market opportunity. Littunen and Tohmo (2003), who adopted Storey's framework to compare the performance of new firms in metal based manufacturing and business services in Finland, confirmed that the founders of high-growth firms were more likely to have been motivated to start their businesses by positive situational pull factors. Passion is a strong indicator of entrepreneurial motivation and is often critical in persuading potential investors, employees and customers to invest time and effort in a new venture (Chen, Yao & Kotha, 2009).

Human capital attributes of technology entrepreneurs enable them to generate the breakthrough insights that lead to radical innovations. Due to the individual, non-contractible nature of entrepreneurial judgment and the high costs necessary to coordinate

knowledge dispersed among different individuals (e.g., Hodgson, 1998), the distinctive capabilities of HTNVs are closely related to the knowledge and skills of their founders (i.e. the human capital of the firm). In turn, this depends on what founders have learned through formal education and prior professional experience. Higher levels of formal education have been associated with greater open-mindedness and receptivity to innovation (Kimberley & Evanisko, 1981). Colombo and Grilli (2005) suggest that HTNVs established by individuals with greater human capital should outperform other HTNVs because of their unique capabilities, and argue that the "capability effect" of founders' human capital explains its positive impact on the performances of HTNVs. However, although for many entrepreneurial founders greater experience is associated with higher levels of success (Singer, 1995), it has also been seen to limit strategic flexibility (Hitt & Barr, 1989).

Previous functional, technical and managerial experience has been identified by a number of researchers as providing knowledge critical to the growth of the firm including marketing, human resource management, communication, financial management and managing change (Smith & Gannon, 1987; Sexton et al., 1997; Carson & Gilmore, 2000; Kakati, 2003). Loasby (1995) suggest that entrepreneurial judgement benefits from learning by doing, as it is a cumulative process of identification and discovery. Managerial tasks such as being able to organise and control the work of employees can only be learned by experience.

Siegel et al. (1993) showed that in a sample of around 1600 Pennsylvanian start-ups, the fact that the entrepreneurial team had prior experience in the same industry of the new firm was the only discriminating factor between high- and low-growth firms. What founders know and can do is very much related to what they learned in the organisation by which they were formerly employed (Cooper & Bruno, 1977; Cooper 1985; Colombo & Grilli, 2005). Therefore, the new firm can exploit the knowledge about technologies, customer needs and competitor strengths and weaknesses, and the contacts with potential customers and suppliers that founders developed in their previous occupation (Freeser & Willard, 1990; Shepherd & DeTeinne, 2005). Gimeno et al. (1997) suggest a strong positive association between post-entry performances of new firms and index-capturing similarity of customers, suppliers and products and/or services between the new firm and the

organisation by which the entrepreneurs were formerly employed.

Ucbasaran, Westhead and Wright (2008) argue that the human capital required to identify an opportunity may not be the same as that required to exploit it successfully. This echoes Penrose's (1959) view that management talent is a potential blockage to growth, and reinforces the importance of recruiting the appropriate human capital as the firm grows. Penrose (1959:37) argues: "Here [in the process of growth] the imaginative effort, the sense of timing, and the instinctive recognition of what will catch on or how to make it catch on become of overwhelming importance. These services are not likely to be equally available to all firms. For those that have them, however a wider range of investment opportunities lie open than to firms with a less versatile type of enterprise."

Macpherson and Holt's (2007) review of the recent empirical evidence lead them to argue that growth cannot be achieved without managerial capabilities to provide specialist functions and processes designed to support entrepreneurial actions. This confirms Penrose's view of the firm as a function of both entrepreneurial and managerial capability. Fast growing firms are more likely to have a managerial team with a strong vision for the firm and a motivation to grow the business and a sales orientation. Business strategy and the managerial ability for planning the implementation of that strategy are also vitally important (BERR, 2008).

As HTNVs evolve, they require new skills to deliver their product or service to market, which the human capital of the original management team may not have, particularly if they came from an academic technical background (Mosey & Wright, 2007). If the skills are absent within the management team, the required human capital can be recruited as employees (Kaulio, 2003), hired as consultants (Hill et al., 2002), or additional directors can be brought into the management team (Littunen, 2000; Littunen & Tohmo, 2003). The human capital of venture capitalists that invest in young firms can overcome the lack of human capital in the initial founding team (Colombo & Grilli, 2009; Fernhaber & McDougall-Covin, 2009). Although individuals can be hired with the required knowledge, Colombo and Grilli (2005) argue that it can be more effectively coordinated if the individuals with the knowledge required are part of the founding team and have a stake in the firm's future profits. As new staff are brought into the organisation, there is the risk of

the promotional desires of the workforce being denied (O'Neill, 1983) and this can cause barriers to growth. It is suggested that the broader spectrum of previous managerial experience and the resulting human capital become more significant as firms grow (Eisenhardt & Schoonoven, 1990; Wiklund & Shepherd, 2003).

The human capital of SMEs has an impact on the firm's financial capital (see 2.8.2). Despite anecdotal evidence that HTNV founders with greater human capital are more likely to obtain VC funding, the results of studies relating to founder education and experience are mixed (Colombo & Grilli, 2009). The management competency and industry-specific experience of founders are important selection criteria for VC investment (Tyebee & Bruno, 1984; MacMillan et al., 1987, 1988; Muzyka et al., 1996, Shepherd & deTienne, 2005).

2.8.2 The role of financial capital in small firm growth

Although the RBV literature does not advocate that financial resources provide competitive advantage, as it is not rare, SMEs and in particular HTNVs invest a good deal of their available financial capital in product and market development and insufficient finance is often cited as a growth constraint. The conclusions of the Spring 2006 European Council emphasised that adequate access to finance is crucial for the growth of small and medium-sized enterprises. As a result, the Lisbon process offers a framework within which to improve access to finance through reforms at national and EU levels (Commission of the European Communities, 2006). There is substantial evidence that small firms face greater growth constraints and have less access to formal sources of external finance, potentially explaining the lack of SMEs' contribution to growth (Beck & Demirguc-Kunt, 2006). Young firms well-endowed with financial capital during their development period may enjoy advantages and can therefore perform better. Lee, Lee and Pennings (2001:619) argue that a firm that invests more financial resources in its development period will accumulate a larger stock of strategic assets that can provide competitive advantage. On the other hand, firms with less financial capital during their early development may not be able to exploit opportunities in the market place. Earlier research by Roberts and Hauptman (1987) showed that under-financed biomedical firms pursuing significant technological breakthrough exhibited lower performance.

VC funding is an important source of financial capital for SMEs wishing to grow. Trends in the supply of SME finance in the UK also imply that business angels have become even more significant over the past decade for the financing of start-up firms (Mason & Harrison, 2010). This is echoed by George, Wiklund and Zahra's (2005) work on the contribution of venture capital (VC) funding to the performance of the firm. Equity participation by respected VC and angel syndicates signals that the SME is less risky. It has already been highlighted that the human capital of the firm impacts on the likelihood of firms receiving VC funding, but venture capitalists have also been shown to provide the firm with significant human capital and social capital in addition to the equity they have invested.

2.8.3 The role of organisational capital in small firm growth

Small HTNVs are often described as being more flexible and agile than large mature firms. The ability to adapt their strategies to address opportunities and threats that arise in the environment is important to optimise growth. It is the organisational capital (i.e. structures, processes and governance systems) imbedded by founders and implemented as the firm grows that influence the organisational culture and the flexibility that the firm has to adapt and grow. The entrepreneur's ability to create both a suitable organisational systems and activities that support and encourage knowledge transfer, learning and knowledge exploitation is an important antecedent of growth (Macpherson & Holt, 2007). For example, Nelson and Winter (1982) highlight tried and tested 'routines' implemented by the entrepreneur that benefit the growth of the firm.

Organisational culture is another key aspect of organisational capital and an important antecedent for growth, and is strongly influenced by the founding entrepreneurs (Baron et al., 1999; Sadler-Smith et al., 2001; Barnett & Story, 2001; Gray & Gonsalves, 2002). Researchers emphasise the entrepreneur's role in creating an environment that supports innovative behaviour, in which knowledge and learning is valued (Macpherson & Holt, 2007). In the dynamic high-technology industries in particular, this has a significant impact on how knowledge is acquired and assimilated and the ACAP of the firm, which in turn influences the ability to recognise opportunities for growth.

The process of growth brings necessary changes in the complexity of the formal structures in the firm. The number of levels and divisions are likely to increase within areas of specialisation (Penrose, 1959; Blau, 1970). During growth surges, tensions between systems of control and empowerment need to be resolved (O'Neil, 1983; Fombrum & Wally, 1989). The investment required to finance growth strategies often leads to a change in the governance of the firm and can impact on the firm's ability to respond to opportunities. However, threshold firms undergoing a change in governance can leverage the knowledge of new board members and VC representatives to enhance the firm's ability to exploit opportunities (Zahra et al., 2009).

A review of empirical studies suggests that organisational capital does play a significant role in the firm's ability to leverage knowledge, but a deeper understanding of the way in which these processes are embedded in the firm in order to support growth is needed (Jones & Macpherson, 2006).

2.8.4 The role of social capital and networks in small firm growth

Empirical research in the area of small firm growth points to the social capital of the firm being instrumental in accessing the external knowledge that the firm requires (e.g., Lee, Lee & Pennings, 2001). Both the network approach to internationalisation and the open model of innovation highlights the importance of access to external knowledge, and the facilitating role of networks as drivers of growth. Other aspects of management research also point to access to knowledge as a critical success factor, and social capital has been shown to have a moderating influence in accruing resources including knowledge from social interaction with network ties. (See Lee (2009) for a systematic review of social capital literature relating to business and management.) This chapter has already highlighted the importance of external knowledge to the growth of the firm. In particular, tacit market knowledge and technical know-how have been shown to be of key importance for the HTNV to develop and implement successful growth strategies. Although personal networks are important in the initial stages of growth, they quickly outlive their usefulness (Macpherson & Holt, 2007). Yli-Renko et al. (2001) highlight that social capital facilitates knowledge acquisition in HTNVs through key customer relationships, again reinforcing the importance of building relationships to access to the market. Experienced entrepreneurs

in a commercial environment are likely to have access to more diverse resources through their social networks (Callon, Laredo & Mustar, 1997). Prior commercial experience provides entrepreneurs with established relationships, a positive reputation and credibility with key actors. By contrast, less experienced entrepreneurs with more limited social networks may lack access to seed finance, industry knowledge to recognise opportunities, or access to investment finance (Mosey, Lockett & Westhead, 2006). Less experienced entrepreneurs have less of a reputation in the markets and may be unsure how to develop it (Davidsson, 2002; Mosey & Wright, 2007). It has also been found that academic entrepreneurs lack the social capital required to develop the firm, as their social networks are constrained by a narrow scientific research network. Many academics only have weak ties with actors located out-with their department (Granovetter, 1973), although some build good networks with industry actors, that enable resources to be accessed (Mayer & Schooman, 1993). Furthermore, successful knowledge transfer and learning through networks requires specific social skills. Effective and co-operative network interactions require either attitudinal (Tjosvold & Weicker, 1993) or relational (Perren 2002) competencies or both (Blendel & Hingley, 2001).

In HTNVs (academic and non-academic) the shortcomings of the social capital of the founders can be successfully supplemented by more experienced board members and venture capital networks (Zahra et al., 2009). Venture capitalists in particular, because of their ownership, have an incentive to share their network of contacts with the firms in which they invest (Fernhaber & McDougall-Covin, 2009). Different types of formal networks have been found to support the growth of the HTNVs by bridging the knowledge transfer between actors. These include industry cluster networks (Staber, 2001; Dijk & Sverrison, 2003); Government support programmes (Westein et al., 1992; Bessant, 1999; Cooke & Wills, 1999); knowledge bridging activities by the technology transfer offices of universities (Jones & Craven, 2001; Lipscomb & MacEwan, 2001; Iles & Yolles, 2002); industry trade bodies (Inkpen & Tsang, 2005), and; venture capitalists (Barney et al., 1996).

2.9 Models of firm growth

The significant interest in firm growth has led to a considerable body of literature attempting to model the growth process. The most frequent theoretical approach to understanding business growth has been stage growth models, in which predictable patterns of growth of organisations are assumed to exist and unfold as discrete time periods described as stages (Scott, 1970; Smith, Mitchell & Summer, 1985). Lippitt and Schmidt (1967:102) introduced the 'life cycle approach' to stage models, suggesting that "as a business organization goes through stages of birth, youth, and maturity, it faces a predictable series of crises ... Like people and plants, organizations have their life cycles". The description of growth as a life cycle where firms go through a linear transition from birth to maturity has been criticised by many (Levie & Hay, 1998; Stubbard & Smalley, 1999; Rutherford et al., 2003; Levie & Lichtenstein, 2010). As this thesis was drawing to a conclusion, Levie & Lichtenstein (2010) published a systematic review of the stage model literature from 1962 to 2006, concluding that there is little agreement (from 104 models) on a stages theory of business growth or a framework to explain how growth and development occur over time.

Kazanjian (1988) also critiqued the existing stage models, arguing that they offered little explanation of why the characteristics of a particular growth stage emerge, and that they only imply the determinants of a firm's position in a particular stage of growth and the factors that precipitate a shift form one stage to another. He also asserts that the previous models do not take into account the role of industry, technology or other situational variables. Kazanjian (1988), drawing on the crisis and revolution implicit in the models of Greiner (1972) and Churchill and Lewis (1983), employed a multi-method research design which resulted in his model (see table 2.7) which describes the dominant problems that occur at the different stages of growth of HTNV. He emphasised that it is not the problems found at each stage that are important, but the transition from stage to stage and the organisational learning process. Kazanjian and Drazin (1990) develop this further, noting that centralisation of decision making decreases as firms move to higher stages, while formalisation of decision making increases and the development of specialised roles (such as marketing and manufacturing) increases. However, they found that in HTNVs, specialisation in technology functions remains high across all stages. The implications for

Table 2.5 Kazanjian's stages of growth

Stage	Characteristics	Problems associated with stage
Stage 1 Conceptualisation and development	Before their formal creation, signified by incorporation or by gaining financial backing that goes beyond seed grants, all ventures go through a period during which the primary focus of the entrepreneur(s) is on the invention and the development of a product or a technology. Structure and formality are non-existent	Problems associated with resource acquisition and technology development higher than firms in other stages
Stage 2 firms Commercialisation	Given financial backing, new ventures go through a period where their major focus is on developing product or technology for commercialization. The organisation resembles a new product development team, Some functional teams have been created, others are embryonic	Problems associated with production start-up, vendor relations, facilities and field support of the product higher than will firms in other stages
Stage 3 firms Growth	If a product is technically feasible and achieves market acceptance, a period of high growth will typically result, A constant state of change, growth of hierarchy, advent of functional specialisms and addition of professionally trained experienced management	Problems associated with sales growth, market share growth, and internal organisational mechanisms higher than will firms in other stages
Stage 4 firms Stability	Growth rate slows to be consistent with the market rate. Typical focus is on the development of second-generation product(s)	Problems associated with profitability, internal controls, and future sources of growth higher than will firms in other stages

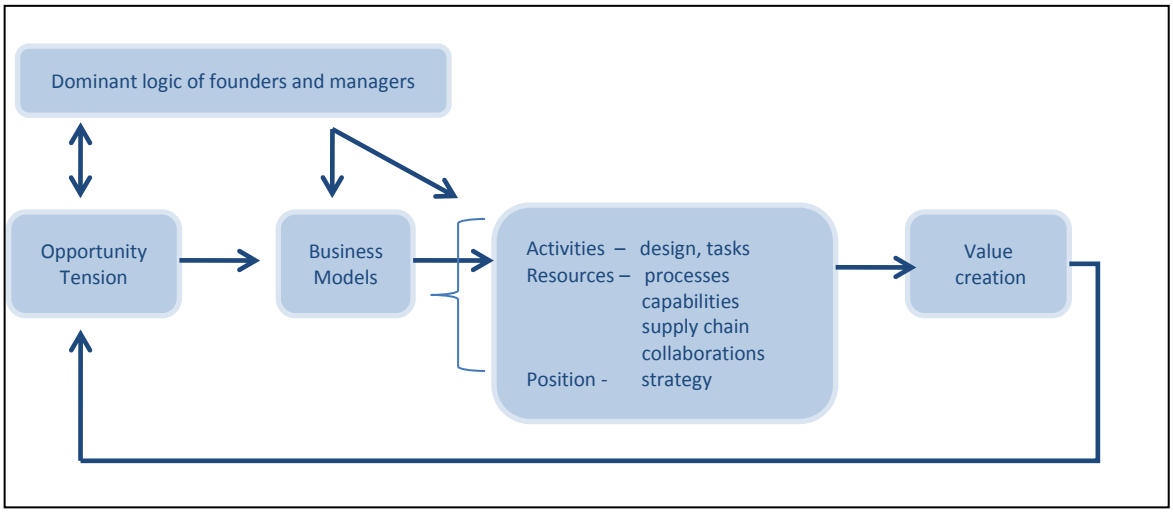
Source: Tabulated from Kazanjian (1988:262-266)

managers from this work is the importance of managing the transition between phases of growth and selecting the right structure, as the firm will grow faster if the structure allows it to. This view is echoed by Miller and Friesen (1983), who argue that as a firm increases in size, managers face a number of problems and more sophisticated capabilities are required for the firm to continue to grow. Similarly, Vohora, Wright and Lockett (2004) identified four 'critical junctures' in the development of technology-based academic spins-offs: opportunity recognition, entrepreneurial commitment, threshold of credibility and threshold of sustainability. These states apply to all HTNVs, not just those from an academic background. Members of the entrepreneurial team change as the firm evolves.

Levie and Hay (1998) propose a 'states framework' wherein a firm's growth is not a predictable sequence of stages characterised by increasing size and age, nor is it a predictable sequence of problems to overcome. It is described as a complex, path-dependent process unique to each firm through which encounters are recognisable as 'tipping points' (Gladwell, 2000). To continue growing, the firm must successfully resolve the challenges presented by the tipping point.

This states approach is developed further by Levie & Litchenstein's (2010) 'dynamic state' approach to growth (Figure 2.10). This approach retains what Levie & Litchenstein describe as the most intuitive and accurate propositions of the stages approach, while including insights from recent entrepreneurship literature. It builds on the concept of punctuated equilibrium (i.e. periods of stability followed by crisis) that features in some life cycle models proposed by Churchill & Lewis (1983) and Griener (1972). However, it aims to reflect an optimal relationship between the firm's business model and its environment. As environmental conditions change, organisations can make a transition between states and these transitions are faster in more dynamic environments. Transitions can also be in reverse as markets shrink. A dynamic state is proposed to be "a network of beliefs, relationships, systems and structures that convert opportunity tension into tangible value for an organisation's customer/clients, generating new resources that maintain the dynamic state"(Levie & Lichtenstein, 2010:336). They claim that their states approach is more flexible than the stages approach and they argue that with flexibility and awareness of continual change in the environment, entrepreneurs can anticipate the demands of their market more successfully.

Figure 2.9 Elements of a dynamic state approach to small firm growth



Source: Levie & Lichtenstein (2010:332)

The 'states approach' suggests that "rather than assuming growth, a more sustainable approach would be to find the most effective an efficient dynamic state between the entrepreneur, her or his organization, and the niche market" Levie & Lichtenstein (2010:337).

Furthermore, Macpherson and Holt's (2007) review of literature on firm growth, notes that unlike Greiner's (1972) stage model where internal structures provided solutions to growth problems, in more recent years, solutions have been dependent on access to specific knowledge resources and available experience to resolve challenges that arise. Thus they conclude that firm crises and their solutions are more complex than a simple transition between stages of growth (Watts et al., 1998; Macpherson et al., 2004; Bessant et al., 2005; Macpherson & Holt, 2007; Phelps, Adams & Bessant, 2007).

This section has reviewed the attempts in the literature to model the growth of small firms. However, an examination of both the theoretical and empirical literature reveals that the growth process of small firms is more complex and challenging than the stage growth models portray and concludes that firms are unique in the combination of challenges they face. The next section highlights that firms learn as they work through challenges associated with points of crisis or critical events, in order to move forward to the next stage of growth.

2.10 Critical events – 'tipping points' to learning and growth?

Critical events for the firm can stem from external sources or be proactively generated internally to achieve an objective (Kim, 1998). When responding to a crisis event, Clarysse and Moray (2004) suggest that the learning process is often rapid for the firm, forcing the entrepreneur to seek support and alternative sources of knowledge missing from the stocks of knowledge within the firm (Deakins et al., 2000). This view is consistent with Kazanjian's (1988) description of a firm's resolution of problems process, suggesting that the way in which firm responds to a crisis shapes the organisational routines and structure and impacts the future growth. It is suggested that non-linear learning takes place when the firm perceives a crisis and attempts to resolve it (Meyers, 1990). Kazanjian (1988) notes that problems play a central role in the growth patterns of HTNVs and argues that organisational learning occurs when a firm maps the solutions to problems onto its organisation in terms of specific functions, structures and positions, as well as information, decision and planning processes. If learning occurs and the organisation institutionalises the solutions to recurring problems, it can quickly replicate the solutions when needed. This echoes Miles and Snow's (1978) problem-search-resolution process, which notes that

firms face similar problems in each growth cycle. This suggests that finding suitable solutions through organisational learning, and making that learning available across the organisation to appropriate staff, potentially makes the next growth cycle faster.

More recently, the idea of critical events which act as tipping points (Gladwell, 2000) is taken forward by Phelps, Adams and Bessant (2007:13) who suggest that "as firms grow, they encounter a series of problems which, at some critical or threshold level that we call tipping points, must be successfully addressed if growth is to continue". They propose six tipping points: 1) people management, 2) strategic orientation, 3) formalisation of systems, 4) new market entry, 5) obtaining finance and 6) operational improvement, and emphasise that organisational knowledge helps the firm to navigate through them. In proposing this framework, they make no assumptions about linearity, sequence or predictability. "To navigate beyond the tipping point, the firm must have the capability to identify, acquire and apply new knowledge to resolve the new challenges and succeed in the competitive environment" (Phelps, Adams & Bessant, 2007:11). The transition is due to the efficient and effective acquisition and assimilation of new knowledge. Noting the importance of external knowledge as a resource to address these issues, they integrate the construct of absorptive capacity (Cohen & Levinthal 1990) into a capability model which proposes a series of learning states (awareness, knowledge and implementation) that a growing firm may occupy.

Although the models of Kazanjian (1988) and Kazanjian & Drazin (1990) have been critiqued by some (e.g., Shim et al., 2000), their work to identify appropriate management activities for each stage has been developed and extended by others. Part of the critique of stages of growth models is that when applied by practitioners, they risk wasting valuable management time in areas which are not applicable to the particular firm. Instead, it has been suggested that firms should find their own unique solutions to the challenges they are facing. However, Nicholls-Nixon (2005) describes growth as a result of and response to predictable managerial challenges faced by rapidly growing firms, in areas such as transition in the firm's personnel; business model; organisational management structure; financial management; external environment; and the role of the CEO/entrepreneur. This concurs with the factors that have emerged from the review of empirical studies on small firm growth outlined in the previous section.

An entrepreneur's past experience (Honig, 2001; Musyck, 2003) and perception of the environment (Nicholls-Nixon et al., 2000) influences how the firm responds to the crisis, and hasten the speed of growth (Kazanjian, 1988). As firms grow they require more cognitive heterogeneity in order that management team members may effectively challenge each other and arrive at better strategies (Wright et al., 2007). Zahra and Filatotchev (2004) build on the concept of a 'threshold firm': an intermediary stage between start-up and established firm. These are firms that have survived the early challenges of their existence and are now struggling to develop new skills that match the opportunities and threats they are likely to encounter as they move to the next stage of their organisational life cycle (Daily & Dalton, 1992). Strategic flexibility of the entrepreneurial threshold firm requires a high degree of organisational and managerial learning (Zahra & Filatotchev, 2004), which in turn relies on the firm's absorptive capacity. There has been significant research in the field of academic entrepreneurship on the human capital shortages of academic entrepreneurs (e.g., Venkataraman, 1997; Shane, 2000; Franklin, Wright & Lockett, 2001; Siegel, Waldman & Link, 2003; Vanaelst et al., 2006). Zahra, Filatotchev and Wright (2009) explore the choices that young firms face as they move from start-up phase to more 'professional management' stage of their organisational life cycle and how an entrepreneurial culture is maintained as the firm grows.

Key to growth is the absorption of knowledge and solutions to traverse the tipping points successfully (Phelps, Adams & Bessant, 2007). In dealing with these tipping points, the firm needs to grow its absorptive capacity. It needs to become aware of key issues it is facing and it needs new knowledge inputs to provide solutions to the crises and challenges generated at tipping points. The acquisition, assimilation and application of new knowledge, implies a process of learning that is likely to leave the firm better placed to know how to address the next phase of challenges. Building a new network of contacts, and building knowledge about who to contact for knowledge about what, when and how is also thought to be key. Appropriate advice from external agencies such as economic development agency advisors and so forth is thought to be most potent during these transition points 'enabling a small amount of well-focused advice or knowledge to have significant business benefits' (BIS, 2010:90).

2.11 Challenges for HTNVs at critical events

Based on Penrose's (1959) theory of the growth process and previous research on the development of technical knowledge in firms, it has been argued that both processes interact and create tensions between opportunities and costs. Saemundsson (2005) highlights the tension between the growth process and the technological innovation process in young, growing HTNVs and suggest that the logic of growth should take precedence over the logic of technology development, a view shared by others (e.g., Grandstrand, 1998; Pavitt & Steinmueller, 2002). This is a particularly relevant issue in the life science industry due to the high costs of the development of technology. In order to succeed, HTNVs must survive the challenge of simultaneously building the firm, developing the technology, and engaging with potential customers to build demand for the future product or service. This challenge is echoed by a recent research by Onetti et al. (2010), who note that firms must develop internationalisation capabilities while they are developing their technology in order to enable them to compete in what is essentially, in the case of biotechnology, a global industry.

Young HTNVs often base their competitive advantage on their technology, and therefore the firm is often managed according to the rule of technological competition. Saemundsson (2005) argues that although adding new fields of technical knowledge increase opportunities for growth, firms may not be able to manage the associated increases in costs that are needed to exploit those opportunities. Again, this is particularly relevant in the life science industry where development costs are high and there are often problems of firms running out of money before they reach their development milestones. This echoes March's (1991) proposition that knowledge systems are constantly in tension. He suggests that as needs oscillate between exploration and exploitation, knowledge systems must be adapted. Levie and Litchenstein (2010) call this issue 'dynamic tension' between market potential and the desire and commitment to capitalise on that potential.

The choice of different growth trajectories has important implications for the nature of the human capital required by HTNVs. Resolution of growth challenges requires new knowledge which can necessitate additional human capital. New personnel can cause tensions as there may not match the entrepreneurial ethos and culture of the organisation.

Founders and early staff members often have a pioneering spirit of camaraderie and companionship, which growth may change (O'Neil, 1983). Due to the technical focus within the firm, the firm is often lacking in knowledge about internationalisation, a key driver of growth. However, innovative HTNVs are also thought to be more likely to seek out the knowledge they require, and support from government agencies, because their stronger absorptive capacity enables them to better identify and make effective use of external sources of knowledge (BIS, 2010).

2.12 Conclusions and implications

The purpose of this chapter was to review the literature on the growth of HTNVs, examining the role of knowledge and knowledge processes in the growth of these firms. Due to a lack of holistic approaches to the growth and development of HTNVs in the existing literature, this review has drawn from a number of fields of study.

This literature review has examined the main theories of firm growth, highlighting the importance of knowledge as a key resource for growth, and that the ability to manage knowledge within the firm is an essential management capability. Following on from Schumpeter (1934, 1942), many strategic management scholars have recognised that innovation and entrepreneurship are at the heart of the competitive advantage that enables firms to grow. HTNVs have been identified as being different from other SMEs in that they are created with the specific purpose of maximising the return from the technology upon which they were founded and as such, aim to simultaneously develop commercial applications of their technology, while expanding in international markets. As HTNVs tend to operate in global niche industries, internationalisation is an integral driver of growth in HTNVs. In recognition that HTNVs are simultaneously advancing a number of key integrated entrepreneurial processes, the literature review has taken a holistic approach, drawing on the fields of entrepreneurship, innovation and internationalisation, which all highlight the significance of knowledge for the growth of the firm. This review also highlights that the pace of both innovation and internationalisation is moderated by knowledge, and the ability to leverage of knowledge is critical to organisational responsiveness. In particular the timing of knowledge acquisition and the speed of knowledge exploitation is crucial to the growth of HTNVs. Furthermore, these firms,

having limited knowledge resources within the firm depend on external knowledge to enhance their competitive advantage and growth potential.

In addition to innovation and internationalisation, a review of recent empirical evidence identified a number of factors, such as human capital, financial capital, organisational capital and social capital as impacting on entrepreneurship in SMEs. Prior experience has been shown to be a key aspect of human capital, which impacts on the growth of the small HTNVs in a number of ways and impacts on all the other inter-related factors. Social capital is also highlighted as vital in accessing external knowledge for innovation and the commercialisation of the firms' innovations.

A review of the literature on models of firm growth, suggests that the stages theories of growth have also been found to be unrepresentative of how HTNVs actually grow. Despite the significant critique of the stage of growth theories, insights from the development of stages of growth literature point to the importance of assimilation of knowledge and organisational learning to enable firms to develop and grow. Recent literature instead advocates that each firm is unique in the environmental challenges it faces and that practitioners should focus on marrying their strategy to their specific situation. The speed of resolution of challenges at critical events impacts on the firm's ability to grow and develop (Kanzanjian, 1988; Phelps et al., 2007). HTNVs have a high demand for knowledge and due to their lack of internal resources, must be able to effectively absorb external knowledge (Zahra, 1996) and exploit it successfully to enable their growth.

In conclusion, from this review of literature relating to firm growth across many diverse fields of management, this chapter highlights the importance of the acquisition and assimilation and exploitation of external knowledge to the development and growth of HTNVs. Due to the dynamic nature of knowledge-intensive global industries, the speed at which solutions can be found to challenges at critical events impacts upon growth outcomes. Macpherson and Holt (2007) in particular note the need for a better understanding of the tensions and the nature of knowledge acquisition and learning activity in small firms. They advocate narrative and qualitative sense-making approaches that provide a holistic rather than a linear explanation for the growth of small firms, and call for

a deeper understanding of the learning experiences and processes through which sense is made of the knowledge acquired. This review also points to absorptive capacity (ACAP) as being an important capability which differentiates the firm and enhances performance. ACAP is therefore an appropriate research framework to explore the leverage of knowledge by HTNVs. Chapter 3 provides a review of the extant literature on the concept of ACAP.

This thesis takes these conclusions forward, proposing a holistic approach to the exploration of the leverage of knowledge at critical events in the conceptualisation chapter, encompassing key integrated entrepreneurial processes.

Chapter 3

Absorptive Capacity

3.1 Introduction

The previous chapter has highlighted the importance of knowledge for the growth of the firm. Furthermore, for HTNVs, which often have limited knowledge resources within the firm, the necessity to leverage external knowledge is acute. Given the rapid pace of technological change in turbulent high-technology industries, HTNVs operating in that environment must be able continuously to renew their knowledge bases in order to keep pace with scientific advances and market opportunities. As the fields of knowledge required are often diverse, firms must look outwith their boundaries to acquire the knowledge they require to build competitive advantage. Absorptive capacity (ACAP), the dynamic capability to acquire, assimilate and exploit external knowledge, has become a significant construct in the last twenty years, precisely because external knowledge resources are so important for the growth of the firm (Camison & Forés, 2010).

The purpose of this chapter is to introduce the construct of ACAP, exploring its development as a construct, highlighting why it is an appropriate lens with which to explore the leverage external knowledge by HTNVs. This chapter defines ACAP and outlines the development of the construct. It then explores the dimensions of ACAP and the factors which impact on it. The chapter also reviews how the literature presents ACAP in relation to a number of key drivers that have already been outlined in Chapter 2 as being important for the growth of HTNVs.

3.2 Definition of absorptive capacity

Cohen and Levinthal (1989, 1990, 1994), in a series of three papers, provide an evolving definition of absorptive capacity (ACAP), its antecedents and outcomes; these are considered to be the seminal works in the development of this construct. When describing how internal R&D assists with the assimilation of external knowledge, Cohen and Levinthal (1989:569) suggest that the costs of acquiring external knowledge are small at the time of learning because the firm already has invested in the ability to "identify,

assimilate and exploit knowledge from the environment – what we call a firm's 'learning' or 'absorptive capacity'" (see Figure 3.1). Cohen and Levinthal (1990:128) offer the most widely cited definition of ACAP:

"the company's capacity to absorb, defined by its ability to identify, assimilate and apply for commercial purposes know-how generated outside itself."

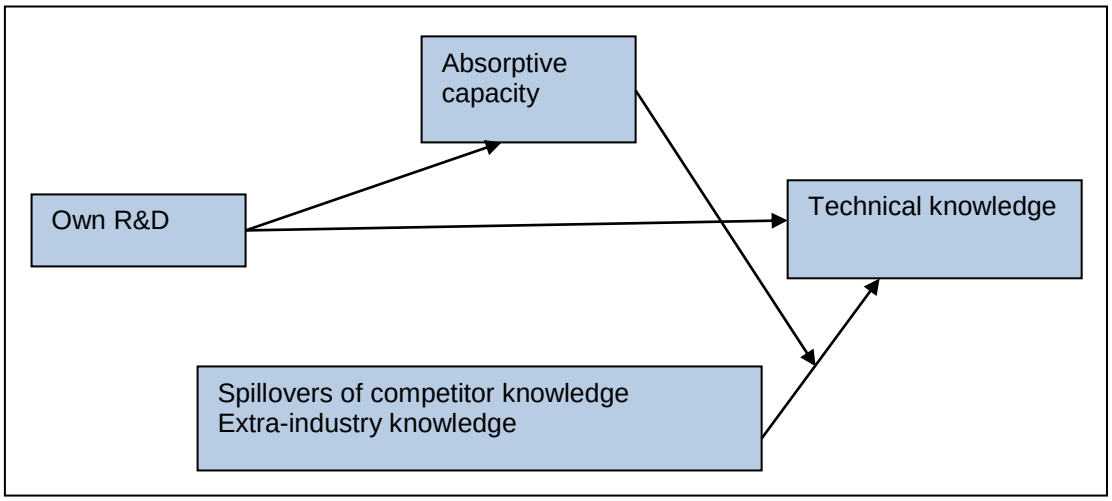
3.3 The development of absorptive capacity as a construct

ACAP pre-dates Cohen and Levinthal (1989, 1990), having been previously discussed by others (e.g., Tilton, 1971; Kedia & Bhagat, 1988). However, it is Cohen & Levinthal's (1989, 1990) more rigorous definition and structure which have allowed the construct to be popularised.

Cohen and Levinthal's (1989, 1990, 1994) conceptualisation of ACAP encompasses a number of key aspects of the construct: The first is the *multidimensional* nature of the construct, involving the ability to value, assimilate and apply/exploit knowledge. The second aspect is the relationship between ACAP and *prior related knowledge*, concerning which they argue that 'the capacity to evaluate and use external know-how is largely a function of prior related knowledge' (Cohen and Levinthal, 1990:128). The third aspect is *cumulativeness*, regarding which they propose that "accumulating absorptive capacity in one period will permit its more efficient accumulation in the next" (Cohen and Levinthal, 1990:136). The combination of these two aspects implies that the development of ACAP is path-dependent. Although they represent ACAP as a capability and discuss it generally across knowledge bases, they equate it empirically with R&D spend, and use R&D intensity as a proxy measure of ACAP, treating it as a static resource (Lane et al., 2006).

In a later paper, Cohen and Levinthal (1994: 229), highlight two components of cumulativeness: Firstly, the way a firm or individual learns is typically based on what they have learned before, and secondly, the development of ACAP is cumulative, in that building ACAP will permit more efficient accumulation in a subsequent period. They also

Figure 3.1 How ACAP enables firms to exploit external knowledge



Source: Cohen & Levinthal (1990:141)

propose that uncertainty increases the value of information and thus in turbulent technical and market environments, the ability to interpret often obscure technological and market signals and to assimilate and exploit technological advances facilitates building competitive advantage. In addition to enabling the firm to exploit new external knowledge, it also allows it to forecast more accurately the nature of future technological advances and to take advantage of emerging opportunities before its rivals can recognise them. Mowery and Oxley (1995) build on this conceptual foundation in their research into strategic alliances, defining ACAP as 'a broad set of skills needed to deal with the tacit component of transferred knowledge and the need to modify this imported knowledge.' Chapter 2 has outlined the importance of tacit information for innovation.

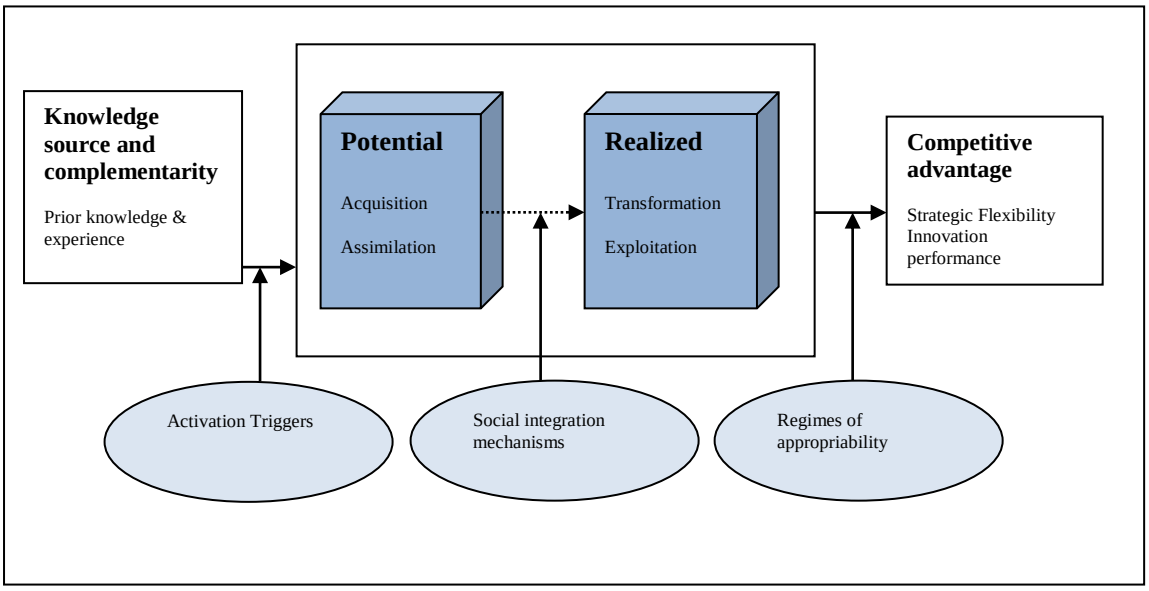
Although Cohen and Levinthal (1990:131) incorporate problem-solving skills and learning in their discussion of ACAP, their focus is primarily on the R&D capability of the firm (see figure 3.1). Kim (1997a, b, 1998) provides a view from the focus of technological learning, describing ACAP as a wider capacity to learn and solve problems that enables a firm to assimilate knowledge and create new knowledge. Since recent small firm growth models explored in Chapter 2 focus on the transition of the firm through growth challenges, using external knowledge to resolve problems, ACAP is therefore a particularly useful lens to examine this phenomenon.

Van den Bosch et al.'s (1999) main contribution to the construct was to suggest that organisational forms and combinative capabilities are organisational determinants and antecedents of ACAP, and that these determinants are influenced by the environment within which the firm exists. They argue that in turbulent environments the firm is likely to dedicate efforts to increasing its ACAP, and changing organisational forms and combinative capabilities to facilitate the leverage of knowledge. Van den Bosch et al. (1999:560 & 566) also introduce feedback loops in their ACAP framework, suggesting that an increase in ACAP causes a change in prior related knowledge in such a way that the firm's ACAP is increased. They also note the impact of the knowledge environment on a firm's knowledge strategies, suggesting that in a stable environment, the focus of knowledge absorption will be on exploitation, whereas in a turbulent environment, the focus is on exploration.

Research on dynamic capabilities of the firm (Teece et al., 1997; Eisenhardt & Martin, 2000; Raff, 2000; Zollo & Winter, 2002; Zott, 2003) offer new insights into the study of ACAP, suggesting that as a dynamic capability, it is embedded in organisational processes, which enables a firm to reconfigure its resource base and adapt to changing environment to maintain competitive advantage. The majority of dynamic capability literature does not mention ACAP specifically; however the construct describes processes and routines within firms that lead to knowledge creation, knowledge assimilation and ultimately value creation. Zahra and George (2002b) develop the connection, reconceptualising ACAP as a dynamic capability, they define ACAP as a set of organisational routines and processes by which firms *acquire, assimilate, transform, and exploit* knowledge, and exists as two subsets of 'potential' (PACAP) and 'realized' absorptive capacities (RACAP) (Figure 3.2). The former consists of acquisition and assimilation and the latter of transformation and exploitation. They suggest that "PACAP and RACAP have separate but complementary roles. Both subsets of ACAP coexist at all times and fulfill a necessary but insufficient condition to improve firm performance" (Zahra & George, 2002b: 191). The transition from one to the other is enabled by social integration mechanisms, echoing van den Bosch et al. (1999) combinative capabilities. They argue that effective internal knowledge sharing and integration are the critical part ACAP.

Zahra and George (2002b) also suggest that the four organisational capabilities (acquisition, assimilation, transformation and exploitation) build on each other to yield ACAP that influences the organisation's ability to create and deploy the knowledge necessary to build on other organisational capabilities. ACAP has been recognised as a key variable that constitutes a factor for success in the process of technology transfer within organisations, but despite a growing body of literature in this area, definition and operationalisations of this construct vary greatly (Zahra & George, 2002b). It is also a construct that works in the context of individuals, firms and systems of innovation in countries (Zahra & George, 2002b). Although there is growing use of the construct, the study of ACAP remains difficult because of the ambiguity and diversity of its definitions, components, antecedents, and outcomes (e.g., Zahra & George, 2002b; Lane et al., 2006). These issues highlight a need for greater clarity about the domain and operationalisation of this construct (Joglekar, Bohl & Hamburg, 1997; Matusik & Heeley, 2001).

Figure 3.2 A model of ACAP based on Zahra and George (2002)



Source: Zahra and George (2000b:192)

Table 3.1 Dimensions of ACAP as defined by Zahra & George (2002)

Dimensions/capabilities	Components	Role and importance	Citations
Acquisition	• Prior investment • Prior knowledge • Intensity • Speed • Direction	• Scope of search • Perceptual schema • New connections • Speed of learning • Quality of learning	Boynton, Zmud & Jacobs (1994); Cohen & Levinthal (1990); Keller (1996); Lyles & Scwenk (1992); Mowery, Oxley & Silverman (1996); Van Wijk, Van den Bosch & Volberda (2001); Veugelers (1997)
Assimilation	• Understanding	• Interpretation • Comprehension • Learning	Dogson (1993); Fichman & Kemerer (1999); Lane & Lubatkin (1998); Szulanski (1996)
Transformation	• Internalization • Conversation	• Synergy • Recodification • Bisociation	Fichman & Kemerer (1999); Koestler (1966); Kim (1997b, 1998)
Exploitation	• Use • Implementation	• Core competencies • Harvesting resources	Cohen & Levinthal (1990); Dogson (1993); Kim 1998); Lane & Lubatkin (1998); Szulanski (1996); Van den Bosch, Volberda & de Boer (1999); Van Wijk, Van den Bosch & Volberda (2001)

S*ource: Zahra and George (2002b:189)*

Zahra and George (2002b) suggest gaps in previous research, which focused mainly on the relationship between ACAP and innovative output, the firm's realised capacity. They seek to investigate potential capacity, which enables strategic flexibility and sustainable competitive advantage in a dynamic industry context. By further defining the dimensions of the ACAP (Table 3.1) they make a major contribution to the development of the construct. Dimensions of ACAP are discussed further in section 3.4. They also built on the resource-based-view of the firm (Barney, 1991; Penrose, 1959), suggesting that ACAP is a dynamic capability that influences the other organisational competencies, and provides the firm with multiple sources of competitive advantage.

Zahra and George (2002b) recognised the importance of different components of a firm's ACAP and point to future research in the relationship between the components of ACAP and their influence on strategic choices. This reinforces the view of Floyd and Lane (2000) that management plays a key role in changing ACAP by redefining and redeploying the firm's knowledge-based assets (Floyd & Lane, 2000). There are similarities between Zahra and George's model of ACAP above and Shane's (2003) model of the entrepreneurial process (Figure 2.4). Both emphasise the exploitation of opportunities in the environment.

Cohen and Levinthal (1990) distinguish between ACAP at the individual level and at firm level, and highlight the importance of organisational mechanisms that foster communication between individuals and units for the exploitation of knowledge. Liao, Welsh and Stoica (2003), taking an entrepreneurship approach, defend this, and propose that ACAP consists of two major components: External knowledge acquisition and intra-firm knowledge dissemination. Recognising that potential ACAP had received disproportionally less scrutiny than realised ACAP, they investigate ACAP in relation to opportunity recognition (discussed further in section 3.7).

Jansen et al. (2005) develop this communication and organisational themes further, carrying out an empirical study based on Van den Bosch et al.'s (1999) and Zahra and George's (2002b) models, finding that organisational mechanisms associated with coordination capabilities (cross-functional interfaces, participation in decision making and job rotation) primarily enhance a unit's potential ACAP and organisational mechanisms associated with socialisation capabilities (connectedness and socialisation tactics) primarily increase a unit's realised ACAP. Nieto and Quevedo (2005) also state that in order to grasp what the sources of a firm's ACAP are, one should concentrate on the 'way the communications between the firm and the external environment' are organised. This would suggest that if the development of ACAP is to be explored, the dynamics of knowledge recognition, acquisition and knowledge flows within the firm should be investigated.

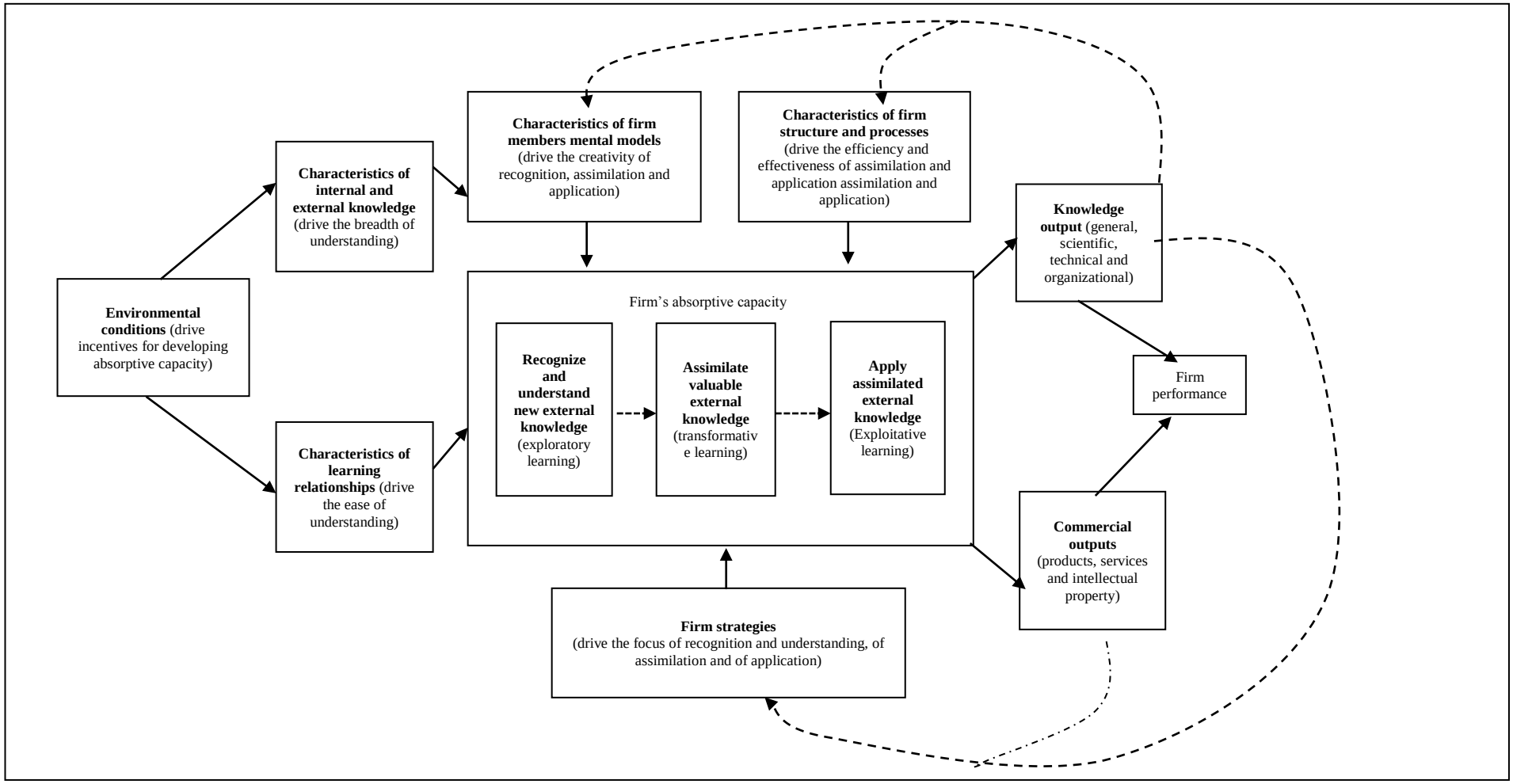
After Zahra and George's reconceptualisation, few studies have examined in any depth the determinants, dimensions or outcomes of ACAP (Vega-Jurado et al., 2008). Lane et al. (2006) in their critical review of peer-reviewed academic papers that focus on ACAP from 1991 to 2002, suggest that the ACAP construct has become 'reified'. A detailed description of 'reification' is provided by Thomason (1988). Lane et al. (2006) emphasise that a construct's original meaning becomes obscured as successive researchers adapt it to fit the needs of their paper and their personal biases (Latour, 1987). They suggest 'Over time scholars unknowingly integrate findings from studies with inconsistent construct definitions, which can create serious threats to validity.'(Lane et al., 2006:835). They also note that 80% of the literature they examined cites the construct of ACAP in a ritual way with little or no discussion. They further observe that the only link that many papers have

to the ACAP construct is the citation of Cohen and Levinthal (1990), and conclude that the ACAP construct has not developed a strong focused research community: "…when the vast majority of the citations turn out to be ritual, the true importance of the construct, the extent to which its assumptions have been tested, and its contributions to a field are overstated. We believe this has happened to absorptive capacity" (Lane et al., 2006:841).

They do, however, acknowledge that the fundamental concept continues to resonate with researchers interested in a wide range of organisational phenomena, and suggest that it has the potential to be a major construct in organisational research. Lane et al. (2006), utilising the same three dimensions of ACAP as Cohen and Levinthal (1990), develop a process model of ACAP (see Figure 3.3) and offer a more detailed 'learning process-oriented' definition of the construct: "Absorptive capacity is a firm's ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning, (2) assimilating valuable new knowledge through transformative learning, and (3) using assimilated knowledge to create new knowledge and commercial outputs through exploitative learning" (Lane et al., 2006:856). Exploratory learning refers to the acquisition and assimilation of external knowledge and corresponds to 'potential ACAP' in Zahra & George (2002b), while exploitative learning relates to applying the acquired knowledge and reflects the 'realized ACAP' in Zahra and George (2002b). The transformative learning step links these two processes, and implies a further level of assimilation with respect to the needs of the firm.

A key contribution of Lane et al.'s (2006:858) model is the acknowledgment that the outcomes of the absorptive process are twofold. Drawing from Cohen and Levinthal's general application of knowledge, this model considers commercial outputs and knowledge outputs and suggests that firm performance is influenced by both. They also highlight internal and external drivers of ACAP. These are addressed in section 3.5.

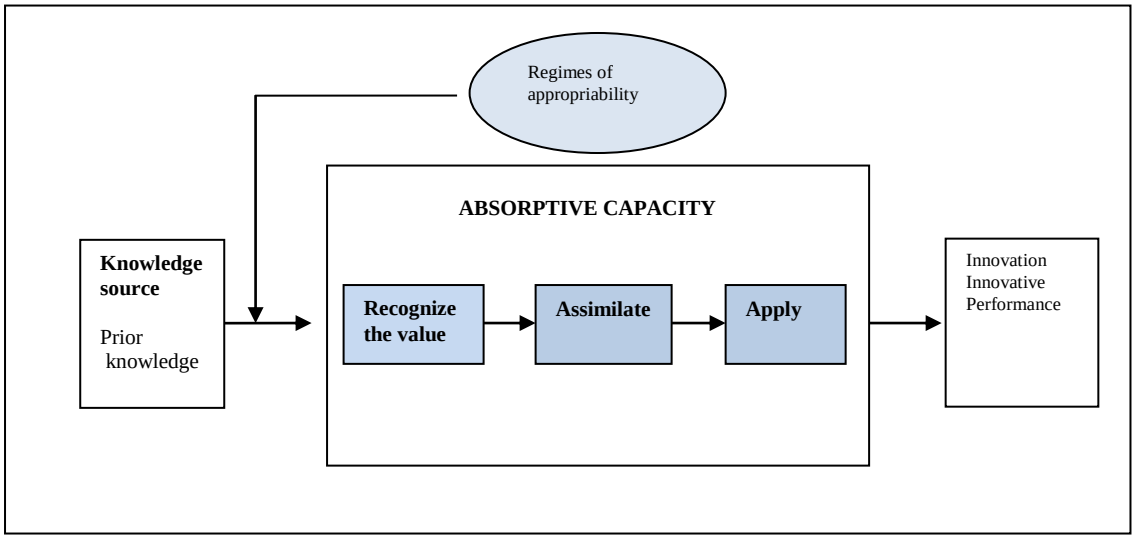
Figure 3.3 A process model of absorptive capacity, its antecedents and outcomes



Source: Lane et al. (2006:856)

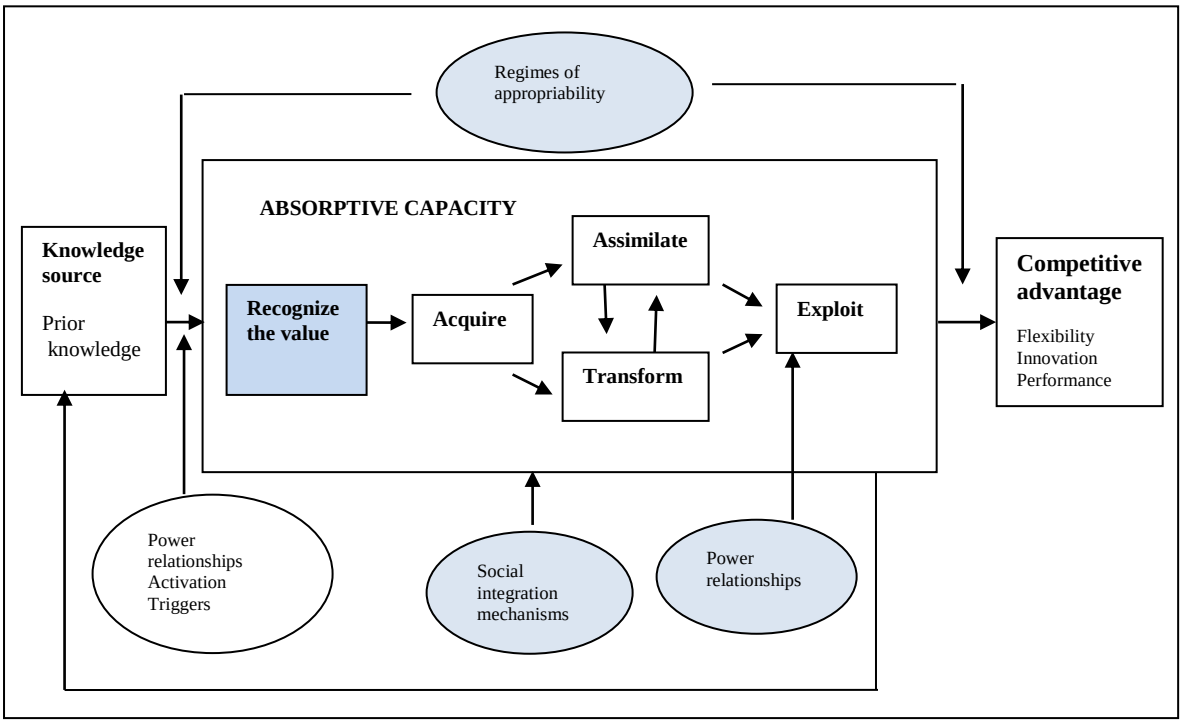
Todorova and Durisin (2007) provide the next significant reconceptualisation of the construct, arguing that Zahra and George (2002b) do not sufficiently build on the key insights from Cohen & Levinthal (1990) and build a model based on their 1990 article (see Figure 3.4). They also claim that the Zahra and George (2002b) model does not make sufficient use of the recent research in learning and innovation and propose a refined model (see Figure 3.5) that advances the ACAP construct. Recognising the value of knowledge, which was emphasised by Cohen and Levinthal (1990), is reinstated as the first step in the process. Power relationships are introduced and have an impact on both the valuing and exploitation of external knowledge. This fits with the literature on entrepreneurship and network theory relating to power distribution discussed in Chapter 2. The major change in this model is the change in the relationship between assimilation and transformation. Todorova and Durisin (2007:775) do not see this process as a series of sequential steps, but as 'an alternative process linked to assimilation by multiple paths'. They also suggest that social integration mechanisms affect more than the connection between assimilation and transformation.

Figure 3.4 A model of ACAP based on Cohen & Levinthal (1990) as interpreted by Todorova & Durisin (2007)



Source: Todorova & Durisin (2007:775)

Figure 3.5 A model of ACAP by Todorova & Durisin (2007)



Source: Todorova & Durisin (2007:776)

Zahra and George (2002b) distinguished between potential ACAP and realised ACAP, but Todorova and Durisin (2007) suggest that once you make transformation an alternative process to assimilation, it becomes part of the earlier potential ACAP, leaving only exploitation in realised ACAP and they therefore argue that the four dimensions should be measured separately rather than in two sets. Todorova and Durisin point to the work of Jansen et al. (2005) who tested acquisition, assimilation, transformation and exploitation as four empirically distinct dimensions of ACAP, rather than as the two subsets proposed by Zahra and George (2002b). Another advance contributed by this model is the addition of a feedback loop to Zahra and George's model, thus reinforcing Van den Bosch et al.'s (1999) discussion of the impact of acquired knowledge on the ACAP of the firm.

Lane et al. (2006) also suggest that there is a recursive relationship between organisational learning and ACAP, a view which is echoed by Sun and Anderson (2010:141) who define ACAP as a learning capability, proposing that "ACAP should be considered a specific type of organisational learning which concerns an organisation's relationship with external knowledge. This is discussed further in section 3.9.

Table 3.2: The evolution of the absorptive capacity construct 1989 – 2010

Authors	Research area	Definition
Cohen and Levinthal (1989:569)	Industrial organization economics	"the costs of acquiring external knowledge are small at the time of learning because the firm already has invested in the ability to "identify, assimilate and exploit knowledge from the environment – what we call a firm's 'learning' or 'absorptive capacity'."
Cohen and Levinthal (1990:128)	Industrial organization economics	'the company's capacity to absorb, defined by its ability to identify, assimilate and apply for commercial purposes know-how generated outside itself.'
Cohen and Levinthal (1994:227)	Industrial organization economics	ACAP not only enables the firm to exploit new external knowledge, but also allows it to forecast more accurately the nature of future technological advances and take advantage of emerging opportunities before its rivals can recognize them.
Mowery and Oxley (1995)	Strategic alliances	'a broad set of skills needed to deal with the tacit component of transferred knowledge and the need to modify this imported knowledge.'
Kim (1997, 1998)	Technological learning	a capacity to learn and solve problems that enables a firm to assimilate knowledge and create new knowledge.
Dyer and Singh (1998, 666)	Inter-organizational cooperation	" an iterative process of exchange leading to relational rents"
Van den Bosch et al. (1999:551)	Organizational structure	"Knowledge environments coevolve with the emergence of organizational forms and combinative capabilities that are suitable for absorbing knowledge."
Liao, Welsch, & Stoica (2003:79).	SME responsiveness Entrepreneurship	"SME's responsiveness is a function of organizational absorptive capacity"
Zahra and George (2002b:191)	Entrepreneurship Dynamic capabilities	"a set of organizational routines and processes (acquisition, assimilation, Transformation and Exploitation) that build on each other to yield absorptive capacity that influences the organization's ability to create and deploy the knowledge necessary to build on other organizational capabilities." "exists as two subsets of 'potential' (PACAP) and 'realized' absorptive capacities (RACAP). The former consists of acquisition and assimilation and the latter of transformation and exploitation. 'PACAP and RACAP have separate but complementary roles. Both subsets of ACAP coexist fulfilling necessary but insufficient condition to improve firm performance"
Lane, Koka and Pathak (2006:856)	Technology management/strategic alliances/external knowledge	"Absorptive capacity is a firm's ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning, (2) assimilating valuable new knowledge through transformative learning, and (3) using assimilated knowledge to create new knowledge and commercial outputs through exploitative learning"
Murovec & Prodan (2009:687)	Innovation	"In order to benefit from information deriving from the market sources of knowledge (such as customers, competition, suppliers etc.), an organization needs to possess sufficient demand pull absorptive capacity. Science push absorptive capacity, on the other hand, enables an organization to benefit from scientific external information (such as information form research institutes or universities)"
Sun & Anderson (2010: 141)	Organizational learning	Absorptive capacity is a learning capability - "a specific type of organizational learning which concerns an organization's relationship with external knowledge"
Camison & Forés (2010:709)	Knowledge management	ACAP is "the systematic dynamic capability that exists in two subsets of potential and realized absorptive capacities. PACAP, which knowledge and acquisition and assimilation capabilities show, capture the firm's efforts expended in valuing, acquiring and assimilating new external knowledge. RACAP, which is the firm's ability to integrate and reconfigure existing internal knowledge and newly assimilated knowledge, and to incorporate this transformed knowledge into the firm's processes, routines and operations, not only to refine existing knowledge and competencies, but also to create new operations and competences.

Source: Summarized from the literature review

The evolving definitions of ACAP as the construct developed in the last two decades are summarised in table 3.2. This summary of the development of the ACAP construct highlights its relevance as a research lens for the exploration of the process of leverage of external knowledge by HTNVs in this study as they aim to resolve the challenges they face at critical events. The next section outlines the dimensions of ACAP.

3.4 Dimensions of ACAP

As described earlier, Zahra and George (2002b) proposed four dimensions of ACAP while Cohen and Levinthal (1990) and many scholars simply describe the application of knowledge as the third step in the process and do not distinguish between transformation and exploitation. The Zahra and George model has been further developed more recently by Todorova and Durisin (2007), who challenge some of the assumptions about the sequence of the steps and re-emphasise some elements from Cohen and Levinthal's (1990) early work. The dimensions of ACAP are outlined below.

3.4.1 Acquisition

The first dimension of ACAP varies slightly in the various ACAP models proposed since the construct's introduction. Acquisition essentially 'refers to a firm's capability to identify and acquire externally generated knowledge that is critical to its operations' (Zahra and George, 2002b:189), although Todorova and Durisin (2007) argue that the first dimension which comes before acquisition should be 'recognizing the value' of external knowledge. For the purposes of this study, this element is assumed to be included within the acquisition. External environmental signals are identified, and information on those signals is gathered and transmitted across the organisational boundary. Cohen and Levinthal (1990) placed importance on the gatekeepers on the boundaries of organisations recognising the value of external knowledge and warned against the risk of 'Not invented here' syndrome within organisations. Gavetti and Levinthal (2000) and others (e.g., Todorova & Durisin, 2007) argued that firms can be hampered by their embedded knowledge base if new external knowledge is a radical innovation that does not fit within current knowledge stocks.

Acquisition also represents a concept that refers to 'active listening'. Liao, Welsh and Stoica (2003) suggest that the generation of external information should be an organisation wide activity and that firms need to scan the environment frequently and broadly. They emphasise that the more knowledge that can be collected over a given period, the better the acquisition capability works and the more options there are to identify changes in the environment, the better the company can perform. As the direction of accumulating knowledge can influence the paths that a company takes, it is important to have different areas of expertise within a company in order to import external technologies successfully (Zahra & George, 2002b; Rocha, 1997). How the relationship between 'shared knowledge and range of knowledge' among individuals affects the development of organisational ACAP.

Cohen and Levinthal (1990) note that although some overlapping knowledge is required for internal communication, benefits are also obtained from the 'diversity of knowledge' between individuals (:545). The diversity of exposure and the degree of overlap between the knowledge bases of the external source and the firm can enhance the firm's potential ACAP (Cockburn & Henderson, 1998; Lane & Lubatkin, 1998; Matusik & Heeley, 2001). This suggests that in order to have a successful transmission of knowledge, a potential knowledge provider should align its offering to fit the ACAP of the firm it intends to collaborate with.

Knowledge acquisition does not automatically mean that the firm will enjoy enhanced performance and growth. Managers must capitalise on the knowledge potential to build competitive advantage (Inkpen, 1998). Information gathered from the business environment must be transferred to the organisation and then transformed through the internalisation process that requires dissemination and assimilation.

3.4.2 Assimilation

Zahra and George (2002b) state that 'assimilation refers to the firm's routines and processes that allow it to analyze, process, interpret, and understand the information obtained from external sources'. Cohen and Levinthal (1990:131) state that exposure to knowledge is not sufficient to develop ACAP. This concurs with earlier information

processing literature (e.g., Lindsay & Norman, 1977:355) and technology transfer literature (e.g., Kim, 1997a, b; Szulanski, 1996) which suggested that the more deeply the external knowledge is processed, the more likely it is that connections will be made with the existing knowledge stock. Brusoni et al. (2005), while focusing on the knowledge bases of pharmaceutical multinational firms, highlight the importance for an integrating firm to 'maintain capabilities on most (if not all) of the bodies of scientific and technological knowledge that impinge on development of specific product market in which they compete'. They go on to say that a 'breadth of knowledge base is necessary for firms interested in maintaining a leading innovative role, playing the role of intelligent customer for the suppliers, being able to recognize at an early stage new and promising technological developments, identifying and abandoning, as quickly as possible, unsuitable development paths'(:397). Henderson (1994) and Henderson and Cockburn (1994) provide qualitative and quantitative evidence that support the fundamental role played by integrative capabilities. Zahra and George (2002b) stress that ideas and discoveries that fall beyond a firm's 'search zone' are overlooked because the firm cannot easily understand them, supporting earlier work (Cyert & March 1963; Rosenkopf & Nerkar 2001) and corroborated by additional research by Rosenkopf and Almeida (2003). Szulanski (1996) shows that external knowledge is context specific, which prevents outsiders from understanding or replicating the knowledge. Liao, Welsh and Stoica (2003) argue that dissemination is the second component of ACAP, and there is no doubt that assimilation of external knowledge involves the communication of the generated knowledge to all relevant departments. Teece (1981) states that comprehension is difficult when the value of the knowledge is dependent on existing complementary assets; however comprehension promotes knowledge assimilation that facilitates assimilation of external knowledge (Zahra & George, 2002b). This again points to the capability of the gatekeeper to communicate not just the knowledge, but what it means for the firm to key personnel across the organisation.

3.4.3 Transformation

Transformation is a firm's capability 'to develop and refine routines that facilitate combining existing knowledge with and the newly acquired and assimilated knowledge' (Zahra & George, 2002b:190). It is the successful integration of acquired knowledge with the firm's existing knowledge and capabilities that solves problems (Kim, 1998) and

creates the development of new capabilities and growth outcomes (Kyriakopoulos & de Ruyter, 2004). Transformation changes the character of the knowledge, though a process of bisociation, which occurs when a situation idea is perceived in 'two self-consistent but incompatible frames of reference' (Koestler, 1966:35). This concept acknowledges the ability of firms to recognise two apparently incongruous sets of information and then combine them to arrive at a new schema. This is also highlighted by Grant (1996b:377), who argues that most organisational capabilities require the integration of specialist knowledge bases of a number of individuals. Todorova and Durisin (2007:779) suggest that assimilation and transformation are not sequential processes and that knowledge can be assimilated through the firm's normal channels after the transformation process has occurred. The process of transformation is thought to shape the entrepreneurial mindset (McGrath & MacMillan 2000; McGrath, MacMillan, & Venkataraman, 1995) as the cognitive structures of individuals are transformed to deal with knowledge they cannot assimilate (Todorova & Durisin, 2007), and therefore enhances organisational responsiveness. Brusoni et al. (2005) highlight the importance of 'depth' of knowledge base in addition to 'breadth', when examining knowledge integration. This is consistent with Shane's entrepreneurship model of opportunity recognition, where he suggests that ACAP allows an individual to frame new information and interpret it in a useful way (Shane, 2003).

3.4.4 Exploitation

Cohen and Levinthal's (1990) definition of ACAP emphasises the application of knowledge. Zahra and George (2002b:190) build on this, stating that 'exploitation is a organizational capability based on routines that allow a firm to refine, extend and leverage existing competencies or create new competencies by incorporating acquired and transformed knowledge into its operation'. Routines allow sustained exploitation of external knowledge over time (Van den Bosch et al., 1999). Zahra and George's (2002b) model also builds on the work of Spender (1996a, b), who suggests that the outcome of exploitation routines is new products, processes, knowledge and organisational forms. This fits with the view of Shane (2003) who also places emphasis on opportunity exploitation in his studies of entrepreneurship, suggests that as true entrepreneurship has a commercial end point, ACAP plays an important role in entrepreneurship. This is discussed further in section 4.6.

3.5 Factors that influence ACAP

Cohen and Levinthal (1994:245) stated that ACAP is an 'important by-product of other activities' and its development is path-dependent (1990). Therefore, significant research in this field has led to an array of factors which have been shown to impact on ACAP. These can be internal or external to the firm and are highlighted in this section. Internal determinants are well documented and summarised by Schmidt (2010) and others such as Daghfous (2004). Unsurprisingly, the literature follows a similar pattern to the entrepreneurship literature. Since knowledge has been shown to be a key resource whose use enables growth, many of the key factors that affect small firm growth also have an impact on the development of ACAP as the acquisition, assimilation and exploitation of knowledge is vital for the growth of the firm.

3.5.1 Internal factors that influence ACAP

- *Investment in R&D*

Mowery (1984) argued that a firm was in a better position to absorb the output of external R&D if it is also performing some amount of R&D itself. In the seminal work on ACAP, the firm's ability to exploit external knowledge is seen as a by-product of the firms R&D (Cohen & Levinthal, 1990). If a firm has no internal R&D capability, this may lessen the firm's ability to utilise the results of external R&D. This focus on R&D has led much of the early research into this construct to use R&D-related proxy measures of ACAP. The continued investment in internal R&D capability increases the stock of knowledge of the individuals involved in this activity and enables the firm to benefit from R&D spillovers (Veugelers, 1997). Other researchers (e.g., Grunfeld, 2004; Schmidt, 2005) suggest that internal R&D is not as important for the absorption of all types of knowledge (Murovec & Prodan, 2009) and point to the importance of a customer focus. However, in fast moving high-technology industries, it is likely that customer-focused staff will also need to have an adequate understanding of the technological advances.

- *Prior knowledge base and human capital*

Prior knowledge consists of prior units of knowledge within the organisation (Linsu, 1998) and it is thought to be one of the most important factors that increase the firm's ability to exploit new knowledge (Daghfous, 2004). Prior related knowledge is thought to enhance ACAP because it enables the firm to acknowledge the value of external knowledge, assimilate it and exploit it commercially (Cohen & Levinthal, 1990). In order to assimilate new knowledge, the firm needs prior knowledge that is related to it (Nonaka & Takeuchi, 1995). ACAP is path-dependent, as it relies on accumulation of knowledge and the corporate memory of the organisation (Zahra & George, 2002b). This view is not universally accepted. Vinding (2006) suggests that cumulative experience does not affect ACAP.

Firm-level ACAP is dependent on the individual human capital within the firm. Human capital is in turn dependent on the prior knowledge of those individuals. The education and skills of employees within the firm have been studied by a number of researchers (e.g., Kneller & Stevens, 2006; Mangematin & Nesta, 1999; Vinding, 2006). Employees with higher levels of education in a particular field are usually better able to absorb knowledge in that field (Daghfous, 2004). Therefore, a firm's ability to exploit external knowledge is dependent on having sufficient numbers of technical specialists (Rothwell & Dogson, 1991). The diversity of employees' backgrounds and knowledge increases the likelihood that external knowledge will in some way be related to the knowledge already in the firm (Daghfous, 2004), but also adds a variety of perspectives from which to process the knowledge that has been acquired, which leads to new combinations and innovation (Cohen & Levinthal, 1990). Grant (1996b) and Davenport and Prusak (1998) point to the importance of knowledge sets that intersect, or 'common ground', enabling communication and allowing the integration of different types of knowledge.

Human resource management practices can have a considerable impact on ACAP. As firms grow and they require new skills, this knowledge is often acquired through recruitment of human capital with the skills required. The ability of these individuals' ACAP to enhance that of the firm is dependent on hiring the right people, but other practices that integrate their skills in the knowledge base of the firm, such as

interdisciplinary workgroups and planned job rotation (Daghfous, 2004) and using reward systems that encourage all levels of staff to develop their knowledge (Davenport & Prusac, 1998). Murovec and Provan (2009) argue that a firm's investment in training is just as important as the initial education of the workforce, because it focuses on the organisation's specific skills needs. Schmidt (2010) agrees with this view arguing that the more education, experience and training employees have, the greater the positive impact on ACAP.

- *Organisational strategy*

Organisational strategy has an impact on the firm's search for knowledge (Lane et al., 2006). Strategy has been shown to have a major role to play in whether external information is internally assimilated and exploited. Organisational inertia, where firms tend to adhere to existing strategies and resist change is a common barrier to the exploitation of knowledge which has been acquired and assimilated from the environment (Davenport & Prusac, 1998:103). Organisational responsiveness can be described as the speed and flexibility with which the firm responds to environmental changes.

- *Organisational structure and intra-organisational communication*

Cohen and Levinthal (1990) put organisational structure at the heart of the ACAP construct, when they argued that it depended on the firm's ability to transfer knowledge across departments, functions and individuals. Company structure often determines what strategies can be applied (Lane, Koka & Pathak, 2006). Grant (1996b:381) also suggests that in developing the KBV of the firm, "organizational structure needs to be designed with a view to organizing activities such as to reduce the extent and intensity of communication required to achieve knowledge integration"; in other words to create a structure that maximizes the ease of knowledge dissemination. He goes on to argue "If the strategically most important resource is knowledge, and if knowledge resides in specialist form among individual organizational members, then the essence or organizational capability is the integration of individual's specialized knowledge" (Grant,1996b:375). This indicates the roles of the individual in the ACAP of the firm and the communication routines that allow knowledge to flow within organisations.

Assimilation is the main aspect of ACAP that is affected by organisational structure as dissemination of acquired knowledge to relevant parts of the organisation is crucial for it to be exploited. Kim (1993) in his research into organisational learning, highlights that an organisation can learn only through its members. Van den Bosch et al. (1999) added to this arguing that the ACAP of a firm is determined by its expertise in stimulating and organising knowledge sharing. Davenport and Prusac (1998) note the importance of linking knowledge producing units with knowledge using units within the firm. Welsch, Liao & Stoica (2001) argue that the firm should be structured to maximise the movement of knowledge through both formal and informal networks. Zahra and George (2002b) highlight social integration mechanisms as a means of increasing the efficiency of assimilation and transformation capabilities. Daghfous (2004) also proposes that to improve ACAP, structure should eliminate bureaucracy, which slows down the ability to assimilate and apply new knowledge due to knowledge distortion as it moves through layers of hierarchy.

Firms tend to structure around specialisations can create barriers to knowledge communication. Gatekeepers that serve as 'boundary spanners' between firm subunits or between the firm and external environment are important to ACAP (Cohen & Levinthal, 1990). Gatekeepers reduce communication gaps and mismatches in cognitive orientation between producers of knowledge and users of knowledge (Daghfous, 2004), which often involves creating a common language (Vinding, 2000). Daghfous (2004) argues that the ACAP of the firm's gatekeepers enhances the process of ACAP.

Cohen and Levinthal (1990:131-132) highlight the relationship between ACAP and intra-organisational communication, positing that "absorptive capacity refers not only to the acquisition or assimilation of information by an organization but also the organization's ability to exploit it. Therefore, an organization's ACAP transfers of knowledge across and within subunits that may be quite removed from the original point of entry. Thus, to understand the sources of a firm's ACAP, we focus on the structure of communication between external environment and the organization, as well as among subunits of the organizations, and also on the character and distribution of expertise within the organization."

Although individual ACAP was highlighted in Cohen and Levinthal's (1990) seminal work, Lane, Koka and Panthak (2006) suggest that the ACAP research community has ignored the contribution of the individual and corporate structure to corporate ACAP. They state "A firm's absorptive capacity is not just a function of industry and corporate characteristics. It also is a function of the personal absorptive capacity of its members, as well as structures and processes of the organizational subunits to which they belong" (:854). How well a firm can aggregate the ACAPs of individuals is determined by its combinative capabilities, formal procedures and policies (Daghfous, 2004). Subramaniam and Venkatraman (2001) found that a higher degree of tacitness of newly-acquired knowledge required richer information-processing mechanisms such as cross-functional teams, frequent communication and experienced staff. Nieto and Quevedo (2005) identified the principal factors having an influence, whether positive or negative, on accumulation of this capacity.

- *Social capital*

Lim (2009) proposes that ACAP is a function of connectedness. This suggests that in order to grasp what sources of a firm's ACAP are, one should concentrate on the way the communications between the firm and the external environment are organised, echoing the views of Cohen and Levinthal (1990:132) in their seminal work on ACAP. This view supports the network theory that suggests that links to many network partners increases the breadth and variety of knowledge to which the organisation has access (Gulati et al., 2000). Tsai (2001) notes a positive impact of a central network position on ACAP. Fabrizio (2009) suggests that an organisation's having more collaboration with university scientists is associated with more exploitation of published research, a higher ACAP, and shorter lag times between the acquisition of the new knowledge and its exploitation as new products. Although there has been extensive research into ACAP and the formal knowledge transfer routes, particularly alliances, the role of social capital as an enabler of ACAP has received limited attention. For example, although the role of gatekeepers has been highlighted as translating knowledge between the external environment and the firm, there has been no attention paid to the nature of the social capital that enables these individuals to access the knowledge the firm requires. Daghfous (2004) suggests that ACAP is determined by the strength of its relationships with other members of knowledge networks. Lane et al.

(2006:856) highlight the impact of social capital on assimilation, suggesting that the characteristics of learning relationships drive the ease of understanding. Given that Chapter 2 highlights the role of social capital for accessing external knowledge, this is a key gap in the ACAP literature.

- *Organisational culture*

Daghfous (2004) suggest that organisational culture or a shared ideology has a strong positive influence on the level of ACAP the firm possesses. The firm's general attitude towards change has a considerable impact on the its ability to embrace environmental changes (Kanter, 1985). Individuals will be more motivated to search for and assimilate knowledge about possible changes if continuous improvement and change is valued in the organisation (Murovec & Prodan, 2009). Where a change-averse culture prevails, although an individual is aware of relevant knowledge, they may not assimilate it into the firm, which prevents absorption (Van den Bosch et al., 2005). Daghfous (2004) notes that when employees are empowered, a knowledge-sharing culture is encouraged and this improves the firm's access to knowledge and the firm's ability to exploit the knowledge it accesses. He argues that the way power is distributed and applied within the organisation has important implications for ACAP as employees that blindly accept instructions are unable to adopt complex learning. This would imply that where a firm adopts a culture of constant improvement and a learning orientation, ACAP is likely to be higher.

3.5.2 External factors that influence ACAP

- *External knowledge environment*

ACAP, as with all firm processes, is embedded in the context within which it operates (Jansen et al., 2006; Levinthal & March 1993). A central component of Cohen and Levinthal's 1989 and 1990 papers was the role of the firm's drivers within the external environment. Environmental turbulence is an element of Liao, Welsch & Stoica's (2003) model (Figure 3.7), but it is not discussed fully. Lane, Koka and Pathak (2006) argue that environmental influences have not been explored in any great depth with the exception of Van den Bosch et al. (1999). Lichtenthaler (2009:824) argues that the lack of attention is

remarkable given that firms often acquire external knowledge specifically to respond to turbulent environments.

The ability to leverage knowledge has a more important role to play in dynamic knowledge-intensive industries where keeping at the forefront of scientific advances is important to maintaining competitive advantage. Firms operating in knowledge-based industries, with typically 'open innovation' models, cannot operate in a vacuum and depend on external knowledge. Firms face the challenge of constantly reevaluating their knowledge base (Grant, 1996b), to incorporate relevant aspects of the knowledge from the external environment. ACAP is essential for this task (de Boer, Bosch & Volberda, 1999).

Scholars have distinguished between technical turbulence, which refers to the rate of technological change (Jaworski & Koli, 1993; Lichtenthaler & Ernst, 2007), and market turbulence, which relates to the degree of instability and uncertainty within a firm's markets (Helfat et al., 2007: Jaworski & Kohli, 1993). Prior research has explored the effects of environmental turbulence on exploratory and exploitative learning (Drogue et al., 2008; Jansen et al., 2006). Lichtenthaler (2009: 837) draws on this work, combining it with the three learning processes of ACAP (Lane et al., 2006) proposing that ACAP has a strong effect on performance in highly turbulent markets, but the strength of this positive effect is reduced in relatively stable environments. Escribano et al. (2009) also suggest that in a turbulent environment, the moderating role of ACAP becomes relatively more important. As HTNVs in the life science industry face both technical and market turbulence, it is an environment which is constantly changing.

- *Regimes of appropriability*

A key part of Zahra and George's (2002b) contribution to the ACAP construct is the introduction of appropriability regimes which moderate the relationship between ACAP and its outcome. However, Todorova and Durisin (2007) suggest that the perceived likelihood of being able to make appropriate returns in investment in an opportunity may impact on the firm's interest in acquisition of knowledge. This is an area which is not well developed in the ACAP literature.

3.6 ACAP and entrepreneurship

The relationship between ACAP and entrepreneurship is explored in two elements: opportunity recognition and organisation responsiveness.

3.6.1 ACAP and opportunity recognition

Shane's (2003) model of the entrepreneurship (Figure 2.4) process parallels Zahra and George's dimensions of ACAP. However, Shane places much more emphasis on the process of exploitation. Shane states "individuals, not groups or firms, discover entrepreneurial opportunities.", and adds "…people discover opportunities that others do not identify for two reasons: first, they have better access to information about the existence of the opportunity; Second, they are better able to recognize opportunities given the same amount of information about it, because they have superior cognitive capabilities" (Shane, 2003:45).

Shane includes ACAP as part of opportunity recognition in his model of 'Individual differences in discovery of entrepreneurial opportunities' (Table 3.4). In particular, Shane points to 1) prior knowledge about markets makes it easier for people to recognize demand conditions, which facilitates discovery of opportunities (Shane, 2000), and 2) knowledge of how to serve markets i.e.: what products or services could be introduced, how these products of services could be produced and distributed, how a new materials could be used in an existing process, or what sources of supply are available (Shane, 2003). This agrees with Von Hippel's (1988) view that prior knowledge of customer needs or problems would increase the likelihood of opportunity discovery because such knowledge facilitates the understanding of how to solve customer's problems when customers cannot articulate their needs.

Research conducted by Reuber and Fischer (1997) suggests that the effect of specific technological advances and international work experience of the founders on the likelihood of international sales in early stages of the firm's life cycle (Reuber & Fischer 1997). In start-up firms, the size of the founding team has an impact on growth. Human capital can be viewed as a source of knowledge, which can be turned into growth. Burgel

et al. (2000) state that the larger the start-up team of owners/founders, the greater the growth prospects of the firm.

Table 3.3: Individual differences in discovery of entrepreneurial opportunities

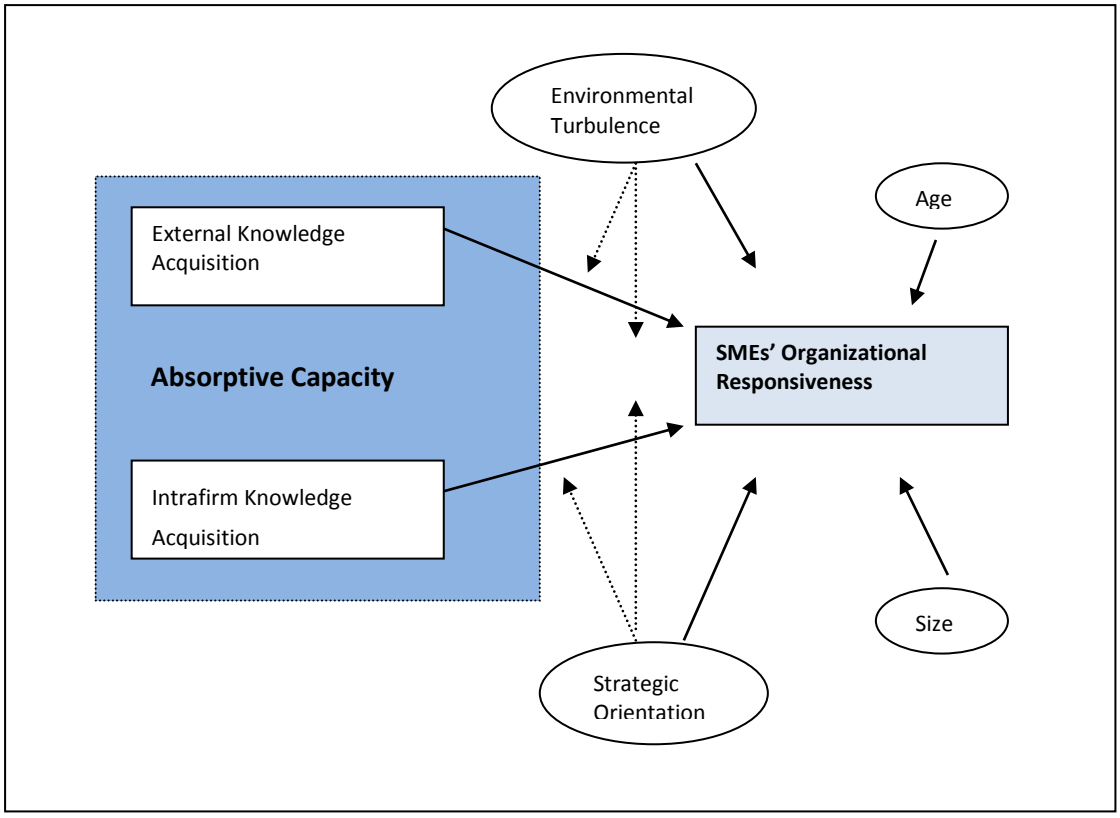
Access to information	**Opportunity recognition**
Life experience	Absorptive capacity
Social networks	Intelligence
Search processes	Cognitive properties

Source: Shane (2003:46)

3.6.2 ACAP and organisational responsiveness

Chapter 2 highlighted that in order for the firm to survive and grow it has to respond to environmental changes, exploiting opportunities and minimising the risks from threats. Organisational responsiveness is important theme in entrepreneurship literature. Despite the wide application of the ACAP concept, little is known about organisational adaptation and responsiveness, and in particular the responsiveness of SMES (Liao, Welsch, & Stoica, 2003). Liao, Welsh and Stoica's (2003) model demonstrating the relationship between ACAP and SME responsiveness is presented in Figure 3.7. SMEs responsiveness represents the dependent variable. ACAP and its components – external knowledge acquisition and intra-firm knowledge dissemination – are the predictors, and size and age are the controlling variables. Liao, Welsh and Stoica (2003) suggest that the relationship is moderated by the environmental dynamism and SMEs' strategic orientation. They find that the two dimensions of ACAP – external acquisition and internal knowledge dissemination to be strong and positive predictors of SME responsiveness, suggesting that both dimensions are important and interdependent. This suggests that they are two inseparable components of ACAP that enable growth-oriented SMEs to respond to their external environments. Welsch, Liao and Stoica (2001) suggest that the greater the firm's organisational responsiveness, the greater its ACAP.

Figure 3.6 ACAP and organisational responsiveness



Source: Liao, Welsh and Stoica (2003:68)

3.7 ACAP and innovation

Cohen and Levinthal (1989) in their seminal work on ACAP emphasise its influence on the firm's ability to innovate. Chapter 2 has highlighted innovation as a key driver of growth for HTNVs, but also that knowledge and innovation are firmly intertwined. Innovation is based on the application of new knowledge and at the same time, the application of new knowledge leads to change and innovation (Daghfous, 2004; Murovec & Prodan, 2009). With the increasing popularity of the 'open innovation' model (Chesbrough, 2003), ACAP has become more important as a dynamic capability that enables firms to exploit knowledge from outwith the boundaries of the firm. To innovate successfully, firms must acquire knowledge from many different fields, but this is only possible if it possesses the ACAP to assimilate it, therefore ACAP has been found to be associated with learning an innovation (Kim, 1998; Mowery, Oxley & Silverman, 1996). It has also been identified by many authors that the greater the breadth in information sources a firm uses, such as customers (von Hippel, 1996) and suppliers (Hartley et al., 1997; Leiponen, 2000, 2002), the greater the effect on innovation outcomes (Rosenkopf & Nerkar, 2001; Ahuja & Katila, 2001; Laursen & Salyer, 2006; Veugelers & Cassiman, 1999). A number of researchers have found a positive relationship between the effective use of external knowledge and new product development (Clift & van den Bosch, 1999; MacPherson, 1997; Moorman & Slotegraaf, 1999). ACAP has been found to influence research productivity in the pharmaceutical industry (Cockburn & Henderson, 1998), inward technology licensing (Atuahene-Gima, 1992), and be a significant explanatory factor in innovation of services in banking (Buzzachi et al., 1995).

Success in adopting and applying new technological knowledge from outwith the firm is largely dependent on the firm's ability to understand it. Such has been the focus of ACAP on R&D, a number of authors have developed definitions of ACAP to reflect its impact on innovation. For example, García-Morales, Ruiz-Moreno and Llorens-Montes (2007) propose that 'technological ACAP is the dynamic capability associated with the ability to acquire and utilize external technological knowledge and know how', whereas Murovec and Prodan (2009:867) define science-push absorptive capacity which enables an organisation to benefit from scientific external knowledge.

- *ACAP and the efficiency of research partnerships*

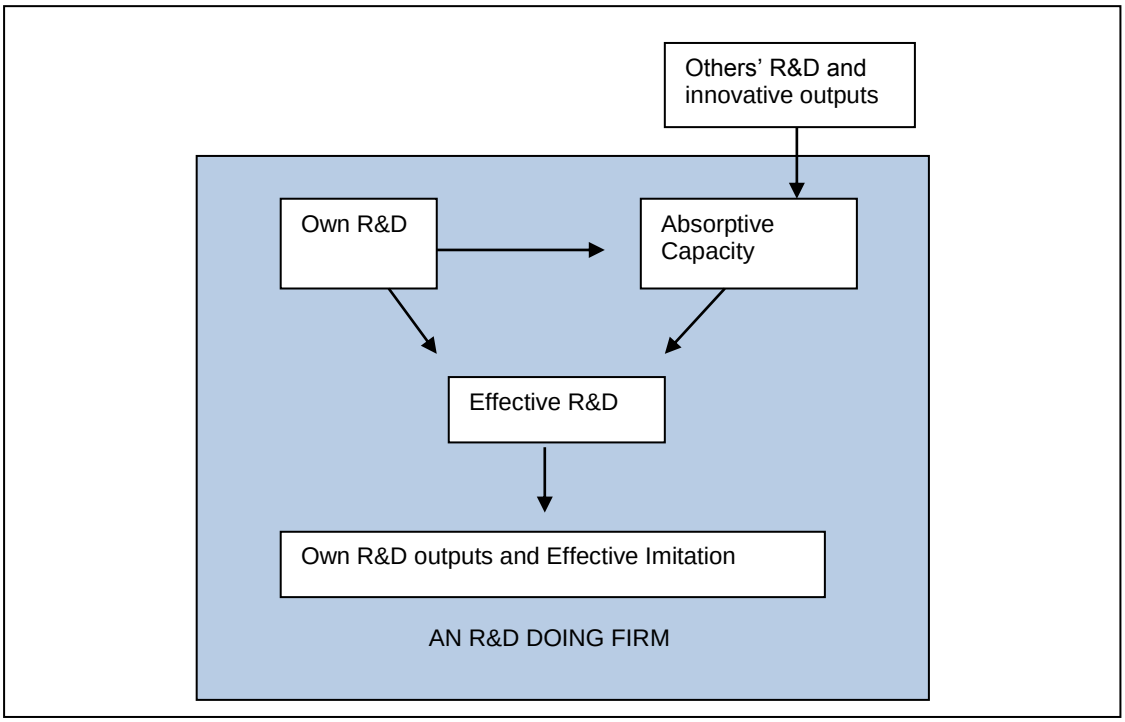
As outlined in Chapter 2, networks of collaborating innovating organisations have become the cornerstone of R&D in the life science industry (Arora & Gambardella, 1994; Pisano, 1991; Orsenigo et al., 2001) and other high technology sectors (Nooteboom et al., 2007) as R&D cooperation increases organisational innovation. Some firms, such as Procter & Gamble, have been shown to achieve significant benefits from external alliances (Huston & Sakkab, 2006), but many have struggled to profit from external knowledge (Cassiman & Veugelers, 2006). In addressing these managerial challenges of transferring inter-firm knowledge, ACAP is thought to be a potential source of competitive advantage (Tsai, 2001). Mowery and Oxley (1995) in their research into strategic alliances, define ACAP as 'a broad set of skills needed to deal with the tacit component of transferred knowledge and the need to modify this imported knowledge'. Zahra and George (2002b) suggest that in order to overcome the barriers to knowledge transfer, firms should proactively develop routines to acquire, assimilate, transform and exploit knowledge from external partners. Lane et al. (2006) reinforce this view with their organisational learning approach to ACAP.

The internal R&D process can be substantially improved by successful partnerships, since many useful ideas are generated outside the company. Partnerships with other companies will enable the firm to view some issues from different perspectives, which, because of established organisational routines and biases, may be difficult to do with only in-house R&D (Scott, 2003). ACAP is thought to be a critical requirement for learning from external relationships. An effective partnership has the potential to make the ACAP from the in-house R&D of the collaborating firms available to the partner firm, therefore expanding its own ACAP.

ACAP, the ability to learn from other firms including research partners, can be enhanced by in-house R&D in the specific area of co-operation. R&D or technical capital enables the firm to build some of the important tacit skills that are needed to absorb the knowledge (codified and tacit) generated by partners (Nooteboom et al., 2007). Management and organisation literature has examined ACAP and the relationships between co-operation and ACAP (Mowery, Oxley and Silverman, 1996; Mowery, Oxley & Silverman, 1999; Kim, 1998; Zahra & George, 2002b). The literature views R&D partnerships and in-house R&D

as complementary strategies rather than alternatives (Scott, 2003). Scott (2003) proposes that research partnerships expand ACAP.

Figure 3.7: ACAP for HTNVs with an open innovation strategy



Source: Adapted from Scott (2003:248)

George et al. (2001) predict that ACAP is required to mediate the relationship between alliance portfolio characteristics and a high technology company's innovative and financial performance (George et al., 2001). Lane and Lubatkin (1998) developed a dyadic construct of alliances, where a student firm absorbs knowledge from a teacher firm that transfers knowledge. Lane and Lubatkin (1998) measured the relative ACAPs of teacher firms and student firms. Tsai (2001) also noted a relationship between the physical characteristics of the alliance network and the ACAP of student firms, on innovation. Chen (2004:318) argues that ACAP has an impact on knowledge transfer performance. Chen found that equity-based alliances transferred knowledge more effectively than contract-based alliances, due to the greater interaction of partners and proposes that this is more appropriate for tacit knowledge whereas contract based alliances are suitable for the transfer of codified or explicit knowledge. This work does not clarify if and how alliance forms impact on ACAP.

The role of ACAP in determining a firm's potential gains from alliances has been theorised (Koza & Lewin, 1998) but not adequately tested (Zahra & George, 2002b; Koza & Levin 1998). The benefits of searching for and accessing novel heterogenous resources have been stressed by a number of authors (e.g., Ahuja & Katila, 2004; Rosenkopf & Nekar, 2001; Rosenkopf & Almeida, 2003). The potential for innovation benefit for firms engaged in more radical exploratory alliances is high, but there is also a greater risk of misunderstanding due to cognitive distance, which has a negative effect on innovation performance (Nooteboom et al., 2007). They argue that a greater ACAP improves the ability to understand and appreciate knowledge at a greater cognitive distance. As this research project was drawing to a close, deJong and Freel (2010) add to this idea, stating that cognitive proximity, which is a direct outcome of investment in the firm's ACAP can overcome any barriers that geographical distance may raise. Firms with higher ACAP can collaborate at greater geographical distance (deJong & Freel, 2010)

In working with partners, some (e.g., Mu et al., 2010) argue that the disseminative capacity is the flip side of ACAP and a successful partnership requires firms to have capabilities in both. Successful exploitation of acquired external knowledge often involves working with further external partners. It takes time for knowledge recipients within partner organisations to assimilate knowledge (Mu et al., 2010). If the knowledge senders have good dissemination capacity, then the transfer of knowledge is likely to be faster. This is also applicable within organisations. It is also potentially worth the gatekeeper of knowledge within organisations being mindful of the prior knowledge and experience of the individuals he/she wishes to disseminate the knowledge to and communicating appropriately to demonstrate the relevance and importance of the knowledge.

Lane and Lubatkin (1998) investigated ACAP and alliances and stated that ACAP is an interorganisational phenomenon that is 'a function of the compatible characteristic of partnering firms'. Building on this work, Newey and Shulman (2004) extend the concept of ACAP from firm level to multiple firms in R&D systems in their conceptualisation of *systemic ACAP*. Systemic ACAP is the cumulative efficiency in the use of ACAP to link changing lead innovators across successive milestone in R&D product development. This is particularly relevant to the pharmaceutical industry where a product can potentially pass from a biotechnology company that discovered it to a pharmaceutical company that

develops it to the point to which it becomes a licensed therapeutic. On the way, the pharmaceutical firm may outsource activity to other partners such as a CRO that performs clinical trials, or a contract manufacturer. Newey and Shulman (2004:498) discuss partners 'passing the baton' back and forth along the value chain and the importance of the pharmaceutical firm to be able to have access and be able exploit the relevant knowledge generated and held by the other firms in the chain. They claim that a system of ACAP is more than an aggregation of the lead innovators' efficiency factors, it is a synergistic evolving R&D system with the integration of the path-dependent ACAP by each lead innovator in the process. It is proposed that the creative exchange between partners of knowledge amongst the product development system partners creates a stock of knowledge that is greater than that of any one partner. The efficiencies of maximising ACAP by each partner effects the overall knowledge production. Newey and Shulman (2004: 495) claim that Systemic ACAP can 'explain performance differences between rival product development systems competing for early to market returns with similar products through accelerating speed to market, cost and quality advantages'.

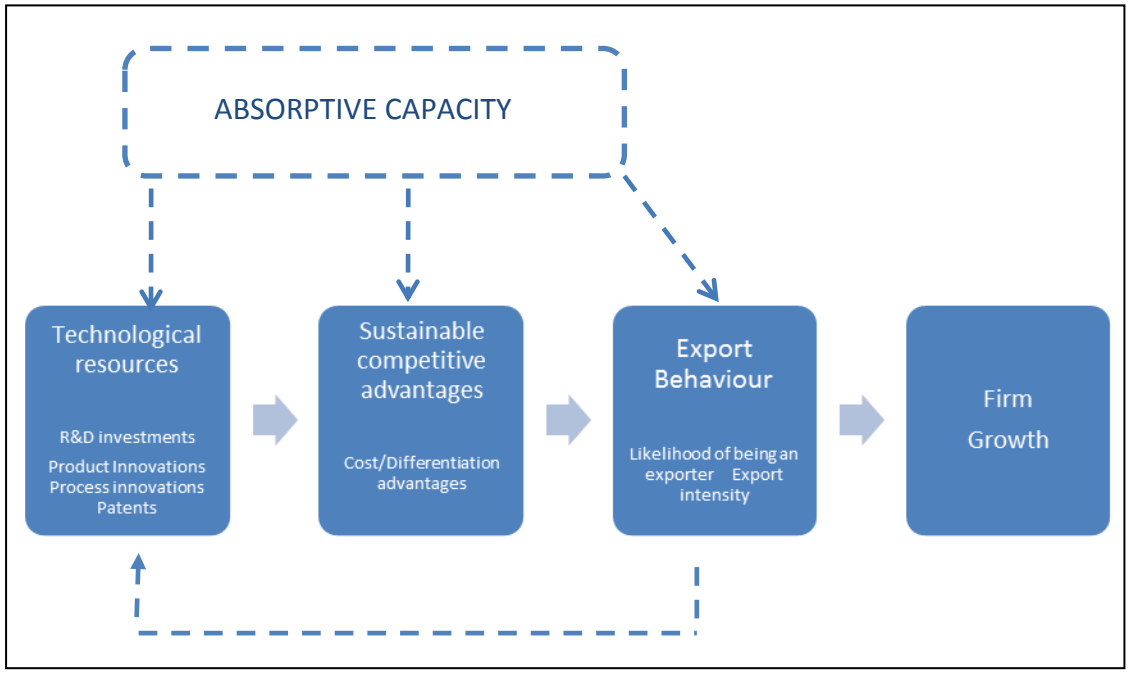
3.8 ACAP and internationalisation

Chapter 2 has highlighted the importance of internationalisation in the growth strategy of HTNVs. Furthermore, as life sciences is a global industry, HTNVs in this industry tend to have an international focus from the outset (Burgel et al., 2000). Barkema and Nadolska, 2003 state that 'internationalizing firms' ACAP increases over time and, moreover, what type of internationalizing experience enhances this capacity' (Barkema & Nadolska, 2003:16). They also demonstrate that firms 'not only benefit from earlier international acquisitions, but also from earlier international experience with international joint ventures.' Oviatt and McDougall (2005:547) argue that "when considering the firm's ability to acquire and assimilate new knowledge pertinent to internationalisation, it is critical to keep in mind the firm's stock of existing knowledge". Firms led by managers with a wealth of international experience are thought to possess greater ACAP.

Chapter 2 has also highlighted the linkages and interdependence between innovation activities and internationalisation activities for HTNVs. From a resource perspective, being exposed to a richer source of knowledge and technology that is not always available

in the home market, internationalising firms can take advantage of these more diverse knowledge inputs from global markets and enhance their knowledge base and build competencies in R&D and innovation (Harris & Li, 2008). Greater innovation occurs when firms search more broadly for knowledge in a variety of technological domains and geographical locations (Ahuja & Lampert, 2001; Ahuja & Katila, 2004; Leiponen & Helfat, 2009). When a firm internationalises, it must absorb new knowledge about how to compete in these markets and the logistics of servicing these markets. Harris and Li (2006, 2009) argue that the development of ACAP is a necessary condition for the successful exploitation of new knowledge gained in global markets and have developed a model drawing on the work of Lopez-Rodriguez and Garcia-Rodriguez (2005), this model has been adapted in Figure 3.8 to include the influence of internationalization on innovation and the growth of the firm.

Figure 3.8 The relationship between technological resources, export behaviour and growth: the influence of ACAP



Source: adapted from Harris & Li (2009)

Barkema and Nadolska (2003) predict that firms increase their ACAP over time, but still expect (based on work done by Cohen and Levinthal, 1990) that the firm's ACAP at any one time is limited. They also predict a negative correlation between a firm's current acquisitions and its other current international expansions at any particular point in time.

They also found no support for the idea that a firm's ACAP is limited at any particular point in time. They point to the fact that managers are often not aware of ACAP, and still less consider whether it is limited.

Eriksson and Chetty (2003) drawing on the process approach to internationalisation, argue that the greater a firm's previous foreign market experience, the greater ACAP it will develop, and in turn the more it understands the need for foreign market knowledge for internationalisation. They also suggest that the firm's foreign market knowledge is determined by dyadic ACAP and customer network ACAP. Fernhaber et al. (2009) argue that when a new venture is able to access international knowledge externally, the reliance on international knowledge sourced by the management team is lessened. This supports the findings of this exploratory study.

Boschma (2005) argues that cognitive proximity is a function of the similarity between organisations' knowledge bases, and can substitute for geographical proximity. de Jong and Freel (2010:48) draw on this work suggesting that there are parallels between cognitive proximity and ACAP in that both start from the proposition that all search processes are constrained by existing knowledge. de Jong and Freel (2010) conclude that high ACAP diminishes the cognitive distance to other innovating actors, enabling firms to collaborate for innovation at greater geographical distance.

Greve et al. (2009) argue that national culture impacts on the ACAP of the firm in an internationalisation context. They suggest that firms that operate in both feminine and masculine cultures, should break down their activities and, where possible, assign acquisition and assimilation activities to more feminine cultures and exploitation to more masculine cultures. This research, although interesting theoretically, does not assist with HTNVs simultaneously innovating and internationalising within a global industry.

Coinciding with the completion of this project, the importance of absorptive capacity as a key factor in firms' ability to internationalise was highlighted in a recent BIS Economics report (2010:89), which, citing results of recent UKTI surveys, notes "Innovative firms are more likely to seek out support, due to their stronger absorptive capacity, as they are better able to identify and make effective use of external sources of knowledge" (BIS, 2010:91)

This report also cites a number of reports commissioned by the DTI including Harris & Li (2009), who suggest that ACAP influences the ability to use information and networks to enable internationalisation, and Bessant et al. (2005) who argue that "there is a need for increased absorptive capacity in order to navigate difficulties associated with growth successfully."

3.9 ACAP and organisational learning

From Cohen & Levinthal's (1989) early definition, it is clear that there is a relationship between organisational learning and ACAP, but there are divergent views as to what the relationship is (See table 3.4). Most studies use Cohen and Levinthal's (1990) conceptualisation of ACAP as both an antecedent and an outcome of learning, suggesting a recursive relationship (Sun & Anderson, 2010). Cohen and Levinthal (1990) suggest that ACAP is a byproduct of prior innovation and problem solving, but in 1994, they suggest that investment in ACAP facilitates problem solving.

Until Lane et al.'s (2006) reconceptualisation of ACAP as sequential learning processes associated with each dimension of ACAP (see page 96), this connection has not been explicit. More recently, Sun and Anderson (2010) highlight previous definitions of organisational learning to emphasise the overlap between the two concepts such as 'the process of improving actions through better knowledge and understanding' (Fiol & Lyles, 1985:803) and Garvin's (1993:80) definition of a learning organisation 'an organization skilled in creating acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge insights'. The ACAP construct also builds on the stream on literature that links 'organizational learning' with innovation. Kim (1998) makes the connection, stating that ACAP requires learning capability and that ACAP develops problem solving skills. Schmidt (2005) also reinforces the organisational learning perspective that points to ACAP being cumulative.

Drawing on Lane et al.'s (2006) conceptualisation of ACAP as three learning processes. Sun and Anderson (2010:141) conceptualise ACAP as a learning capability, arguing that ACAP should be considered as "a specific type of organizational learning which concerns an organization's relationship with external knowledge". As Zahra and George (2002b)

suggest that the dynamic capability of ACAP is a building block that creates new core competencies for the organisation undergoing strategic change, Sun and Anderson (2010) argue that by building ACAP, organisational learning can be promoted, which in turn creates new organisational competencies. Furthermore, it has been suggested that firms need the ability to assimilate, maintain and apply external knowledge and an excessive focus on one learning process is likely to have negative consequences (Lane et al, 2006; Zahra & George, 2002b).

Table 3.4 The relationship between ACAP & OL

Relationship	**Authors**
ACAP is viewed as an antecedent to OL	Kim & Lee (2002), Meeus et al. (2001), Mowery et al. (1996), Oliver (2001)Reagans & McEvily (2000), Szulanski (1996)
ACAP is viewed as an outcome of OL	Liao et al, (2007), Schilling (2002)
ACAP and OL are viewed as having a recursive relationship (both antecedent & outcome)	Autio et al. (2000), Barkema & Vermeulen (1998), Cohen & Levinthal (1990, 1994), Kim(1998), Lane & Lubatkin (1998), Rugman & Verbeke (2001), Tsai (2001), Veugelers (2001)

Adapted from Sun & Anderson (2010)

In order for HTNVs to leverage knowledge to resolve the challenges they face, they must learn from the knowledge they acquire from the environment. Cohen & Levinthal (1990:130) argue that 'problem solving represent a capacity to create new knowledge' whereas 'learning capabilities involves the ability to assimilate knowledge'. They suggest there is no reason to differentiate their modes of development as the preconditions for learning, problem solving and in turn, the creative process of innovation, are similar. Cohen and Levinthal (1990) also suggest that intensity of effort represents the amount of energy expended by organisation members to solve problems (Kim, 1998:507). It involves interaction amongst organisational members to solve problems. The role of ACAP in problem resolution is taken forward into the chapter on conceptualisation.

3.10 Building and managing knowledge stocks and ACAP

Prior to the development of the ACAP construct by Cohen and Levinthal (1989, 1990), Arrow (1969) argued that acquiring knowledge represented a fixed investment that enabled future related exploration and acquisition, but suggested that not all employees would recognise the value of searching for external knowledge and may terminate their search. Cohen and Levinthal (1990) highlight the ability to transfer knowledge internally as being

critical to the development of ACAP. Lennox and King (2004:33) expand on this theme, arguing that as "the best location for acquiring information often differs from the best location for harnessing it, managers' internal policies and programs for information transfer can play a critical role in developing their firm's absorptive capacity". According to Easterby-Smith and Lyles (2003), where organisational learning literature tends to focus on process aspects, knowledge management literature tends to focus on the content of the knowledge that an organisation acquires processes, creates, processes and eventually uses. However both these aspects impact on ACAP. Lennox and King (2004) argue that existing ACAP literature underemphasises the role of managers in administering information to sub-units with unique knowledge stocks within the firm, but since the ability to assimilate information is contingent on related experience, that this ability of managers to develop ACAP is dependent on the distribution of related knowledge and experience within the firm.

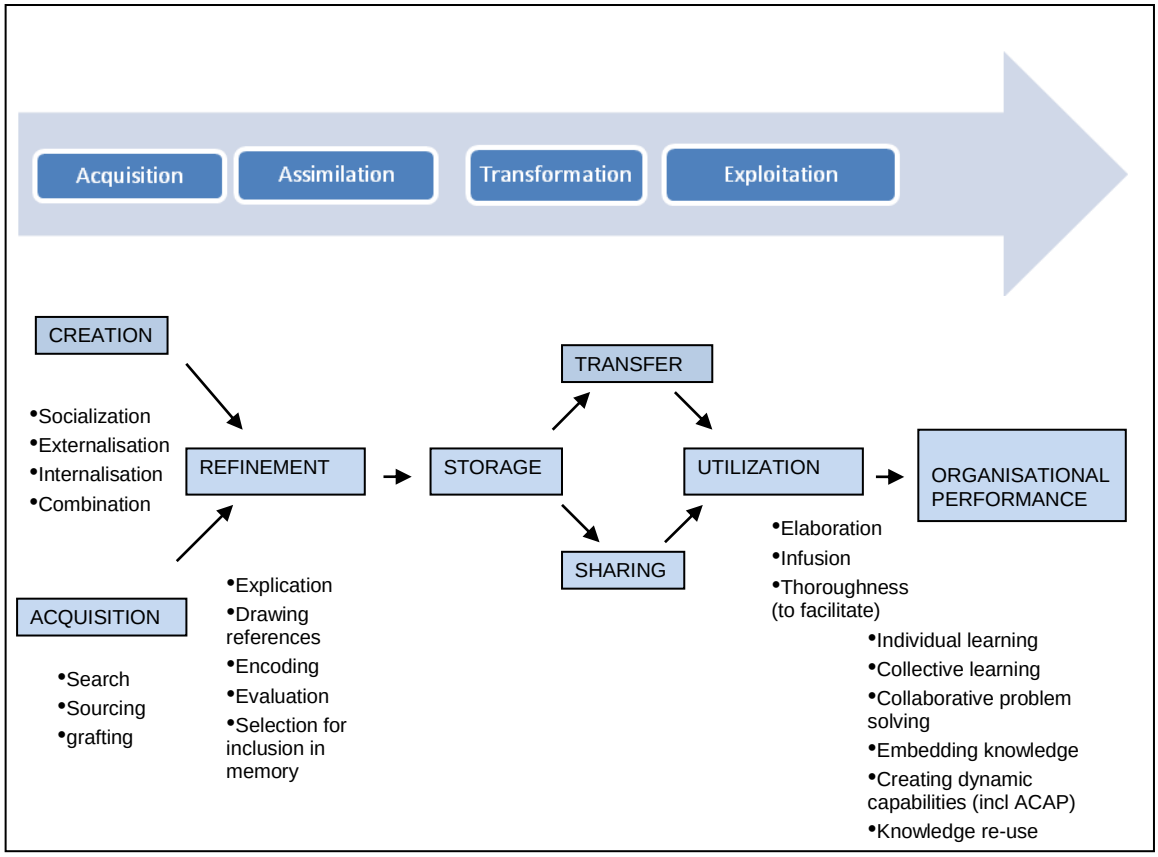
A key task of managers is to accumulate and protect and manage valuable knowledge and capability (Rumelt, 1984; Barney, 1984, Wernerfelt, 1984). Having gained access to external knowledge and appropriate elements of knowledge have been acquired and assimilated, the firm must do something with it to make it available where it is required within the firm. After knowledge has been created or acquired, mechanisms should be in place for that knowledge to be placed in the organisation's memory for long-term reusability (King, 2008). According to Zack (1999), knowledge refinement is the processes and mechanisms used to select, filter, purify and optimise knowledge for inclusion in various storage media. This includes the codifying of tacit knowledge and making it explicit. Once knowledge enters the firm's stores of knowledge, for it to have wide organisational impact, it must be transferred or shared. Transfer involves a purposeful communication of knowledge from a sender to a known receiver (King, 2006a), whereas sharing is less-focused dissemination, such as a repository, to people who are sometimes unknown to the contributor (King, 2006b). Once the knowledge is transferred, it may be used or applied through a process of elaboration (the development of different interpretations), infusion (the development of underlying issues) and thoroughness (the development of multiple understandings by different individuals (King, 2001) in order to be useful to facilitating innovation, collective and individual learning and problem solving (King, 2005). It becomes embedded in the practices, systems, products and relationships

of the organisation through the creation of knowledge-intensive organisational capabilities (Levitt & March, 1988). King (2008) has developed a model which describes the knowledge management cycle. By mapping the dimensions of ACAP to the knowledge management cycle (See Figure 3.9), it highlights that the two processes are very closely aligned and are interlinked. ACAP facilitates and enables the breadth of the knowledge management life cycle and the knowledge management cycle is crucial for the development of ACAP.

A significant proportion of the firm's knowledge may be located in the formal and informal networks of relationships within the organisation and across organisational boundaries (Badaracco, 1991; Coff, 1997; Nelson & Winter 1982; Winter, 1987). Understanding that the location/locus of the firms valuable knowledge bases in the complex social relationships between organisational sub-units rather than individuals is important for the management of the firm's capabilities (Barney, 1991; Kogut & Zander, 1992; Leonard-Barton, 1995), and the generation of new knowledge and capabilities in response to opportunities (Nickerson & Zenger, 2004). No one person has the full set of skills and knowledge required to create a successful commercial product. Retention of key staff is not only critical for retaining individual knowledge but also for preserving the socially complex knowledge.

The development knowledge systems are required to ensure that the knowledge of key staff is available throughout the firm where required, such as the development of standard operating procedures, databases of customer enquiries, records of new product development ideas etc. This also protects the firm for eventualities such as their most valuable assets "walking out the door" to go to work for competitors or to start their own companies (Coff, 1997). There are many studies about knowledge management technology, and although these tools facilitate the ability of firms to retain knowledge they have acquired, this is outwith the scope of this thesis. The formalisation of such knowledge management systems can create rigidities that, while they can improve knowledge transfer and exploitation, they can stifle the flexibility and responsiveness of the small firm (Macpherson & Holt, 2007). Knowledge systems can be constraining if not managed

Figure 3.9 Knowledge management cycle model mapped onto ACAP dimensions



Source: Adapted from King (2008)

appropriately. As the firm grows, and there is less direct control by the founders, there needs to be operating systems that transfer the ethos of the founders to the culture of the organisation as it grows. Easterby-Smith and Prieto (2008) propose that knowledge management-enabled dynamic capabilities are antecedents of organisational and functional capabilities which in turn have a significant effect on business performance. However, to date there has been no study of the impact of the implementation of knowledge management systems on the leverage of knowledge through the ACAP process.

3.11 Conclusions and implications

This chapter has reviewed the ACAP literature, outlining the development of the construct, the dimensions and influencing factors. In reviewing the role of ACAP in the key drivers of small firm growth (entrepreneurship, innovation and internationalisation), this study demonstrates the relevance of ACAP to leverage of knowledge to enable the growth and development of HTNVs.

Knowledge is a key foundation of competitive advantage in knowledge-based industries (Grant, 1996b). Zahra (1996) suggests that HTNVs may not possess the knowledge they require internally and therefore have to gain it form external sources. It is predicted that HTNVs with well-developed ACAP are more likely to adapt to external environmental changes and are more efficient in overcoming the competence traps that lead to a firm's lack of responsiveness.

Cohen and Levinthal (1990) also argue that the development of current knowledge requires resources, and therefore resource-constrained small firms are likely to have both a narrower and shallower ACAP than their larger peers. However, Liao, Welsh and Stoica (2003) suggest that HTNVs with higher levels of ACAP would tend to be more proactive. The literature on the biotechnology industry has extensively documented the ability of HTNVs to capitalise on environmental opportunities more effectively than pharmaceutical MNEs.

The chapter on conceptualisation which follows demonstrates how the construct of ACAP will be utilised as a research lens for this study.

Chapter 4

Conceptualisation and research problem

4.1 Introduction

The purpose of this chapter is to state the aims of the research, make a clear statement of its conceptual stance and the assumptions it makes, and develop the main research question to be addressed through the field work. This thesis explores the challenges facing small HTNVs with respect to their development and growth, and investigates how they leverage external knowledge to resolve these challenges.

The specific focus of this study is the small HTNV within the life science industry, balancing the paradox of long and complex development lead times, and the requirement for instant market access in a global industry to capitalise on significant investment in R&D. Resolving growth challenges enables HTNVs to move forward to the next phase of growth, and requires the firm to acquire and assimilate new external knowledge, combining that with existing knowledge stock in order to provide solutions to the challenges they face (Phelps et al., 2007). These firms are particularly interesting as they are small, inexperienced, constrained in resources, with all the liabilities of smallness and newness, yet their demand for knowledge is acute. Therefore in order to grow, they must effectively absorb external knowledge and exploit it successfully to resolve the challenges they face and move to the next phase of growth. The ability to absorb external knowledge is critical to success.

This chapter firstly draws out key learning from the literature review in Chapter 2. A review of the literature, from the general theories of firm growth, and the fields of entrepreneurship, innovation and internalisation, all emphasise the importance of knowledge and knowledge processes for the growth of the firm. In HTNVs, which have limited internal knowledge resources, this often means the leveraging of external knowledge. Although there has been extensive study of HTNVs, there have been few holistic studies of how firms leverage external knowledge for the transition into a period of growth, including the simultaneous implementation of innovation and internationalisation strategies (e.g., Onetti et al., 2010). Recent thinking in the area of models of growth (see Macpherson & Holt, 2007 for a review), suggests that firms go through growth challenges

or crisis events (Deakins et al., 2000; Clarysse & Moray, 2004) which they must go through in order to grow. The absorption of external knowledge is critical to finding solutions to challenges faced by HTNVs and can be the 'tipping point' (Gladwell, 2000) to enable further growth. However, as March (1991) suggests, knowledge processes are constantly in tension, and need to oscillate between exploration and exploitation. This study examines a number of cases as they leverage external knowledge to resolve growth challenges, thus enabling the next phase of growth. Absorptive capacity (Cohen & Levinthal, 1989), a concept which has been redefined by Zahra and George (2002b) as a dynamic capability that enables the use of external knowledge, would seem an appropriate research lens to investigate the challenges facing these companies.

This chapter continues by summarising learning from a review of literature to date on absorptive capacity and its impact on the knowledge processes within the firm (Chapter 3), leading to a suitable framework to use for this study. This research is exploratory in nature and for this reason the research design is formulated in a series of broad research questions rather than hypotheses, to explore the knowledge processes within these small life science firms as they attempt to solve the challenges they face. In doing so, this research will also shed light on the ACAP process and provide insight into some of the current gaps in the literature that have been identified. Lastly, this chapter presents the line of enquiry for the study, outlining the primary research question and secondary issues of interest.

4.2 Developing the conceptual approach

4.2.1 Aims of the research

The purpose and motivation for this research is grounded in the researcher's interest in how small HTNVs within the life science industry leverage knowledge from their environment to enable their growth. In this dynamic industry, access to timely inputs of knowledge and its subsequent exploitation can be crucial to a firm being able to respond to challenges it faces, which impacts on its ability to grow.

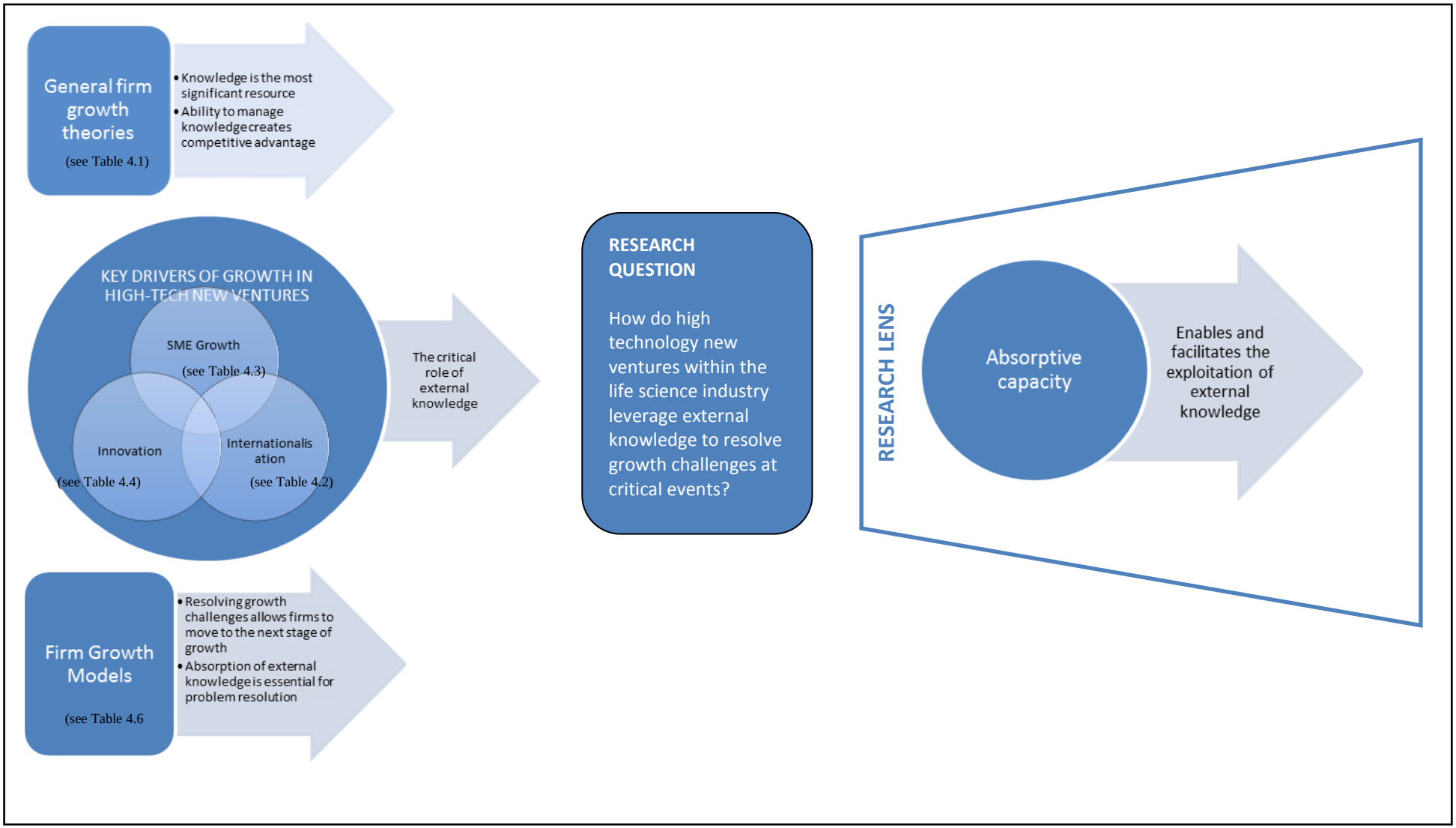
Text Box 4.1 Research Aim

> The principal aim of this research is:
>
> To develop a deeper understanding of how high technology new ventures leverage external knowledge to enable their growth.

The objectives of this research are two-fold: firstly, to evolve theory about the leverage of external knowledge of HTNVs through the ACAP process; and secondly, to provide insights to management teams of HTNVs as to how leverage of knowledge can facilitate the growth of the firm. To achieve these aims and objectives, a number of research questions have been identified. This study takes a holistic approach to the growth of HTNVs, encompassing the three key integrated entrepreneurial processes that drive small firm growth (entrepreneurship, innovation and internationalisation). In doing so, this research aims to contribute to academic knowledge and inspire management to maximise the exploitation of knowledge.

Further development of the theoretical framework presented in Chapter 2 (Figure 2.1 page 17) has led to the conceptualisation process which is summarised in Figure 4.1. The key elements of the line of enquiry in this research project are developed in the following section, 4.2.2.

Figure 4.1 Conceptualisation of research problem and research lens



Source: Developed by the researcher. Key literature is summarised in tables 4.1 – 4.4

4.2.2 Growth of HTNVs and the role of knowledge

The review of several diverse aspects of management literature in Chapter 2 indicates the important role of knowledge for the growth of the HTNV. It highlights that knowledge plays a key role in all other factors that impact growth and therefore cannot be seen independently. It also points to the importance of strategically managing knowledge in order to use it effectively as the most significant resource of the firm. See tables 4.1 to 4.5 for summaries of this diverse literature.

Table 4:1 A review of literature highlighting the role of knowledge in firm growth

General Firm Growth Theories	The role of knowledge and knowledge processes
The Theory of the Growth of the Firm	The ability to identify new opportunities is dependent on the knowledge of the firm's entrepreneurs. The firm's capacity to learn determines the pace and direction of the firm's growth "Managers shape the scope and direction of the search for knowledge." Penrose (1959:77) Limitations to the rate of learning at the individual, team and firm levels restrict both the rate and direction of growth (Kor & Mahoney, 2004)
Resource-based view	Knowledge is a resource and its value is dependent on the firm's ability to use it efficiently and effectively to exploit opportunities and neutralise threats, creating competitive advantage. (Barney, 1991). Knowledge processes are constantly in tension, and need to oscillate between exploration and exploitation (Barney, 1991). Organisational learning is important for resource management (Sirmon, et al., 2007; Zahra & George, 2002b)
Knowledge-based view	Knowledge is the firm's most strategically significant resource (Grant, 1996a; Spender, 1996a). The firm's success is dependent on the knowledge and knowhow of its employees (Grant, 1996 b) and in particular the knowledge processing abilities of its managers (Castanias & Helfat, 1991; Lado et al., 1992) Importance of the firm's ability to access knowledge beyond firm boundaries (Grant & Baden-Fuller, 2004)
Dynamic Capabilities	Emphasis on the acquisition of new knowledge (Eisenhardt & Martin, 2000) and generation of new knowledge and capabilities (Nickerson & Zenger, 2004) The ability to exploit know-how is a key capability (Pisano, 1990) Knowledge codification is key to capability building (Zollo & Winter, 2002), facilitating diffusion, Zander & Kogut, 1995) 2nd order capabilities – single loop learning Higher order dynamic capabilities – double loop learning (Zollo & Winter, 2002)

Source: Summarised from literature review in Chapter 2

The review of theories of firm growth (table 4.1) highlights not only that knowledge is a significant resource for the firm, from the RBV (e.g., Barney, 1991) and KBV (e.g., Grant, 1996a; Spender, 1996a) of the firm, but also the importance of having the capability to exploit knowledge, as highlighted by Penrose's (1959)'Theory of the growth of the firm'

and the dynamic capabilities view (e.g., Eisenhardt & Martin 2000; Pisano, 2000). The ability of managers to recognise relevant knowledge, interpret and disseminate it to relevant staff throughout the organisation, and to combine that knowledge with other knowledge from within and outwith the firm, impacts on the ability of the firm to learn from it. These knowledge processes which result in organisational learning are essential to enable the firm to exploit knowledge resources. Barney (1991) proposes that the knowledge processes of the firm are constantly in tension, and suggests an important role for managers who need to oscillate between exploration and exploitation of knowledge.

Table 4.2: A review of literature - the role of knowledge in internationalisation

Models of internationalisation	**The role of knowledge**
Process models U-model: Aharoni (1966), Johanson & Wiedesheim-Paul (1975), Johanson & Vahlne (1977, 1990), Johanson & Mattsson (1988), Eriksson et al.(1997), Hadjikhani (1997) I-model: Rogers (1962), Bilkey & Tesar (1977), Czinkota & Johnston (1981), (Cavusgil 1980), Czinkota (1987)	• Foreign market knowledge is central to the internationalisation process • A cumulative process of increasing international knowledge and resource commitment which is affected by incremental decisions • Market- specific experiential knowledge is of critical importance • Foreign organizing knowledge is a key regulator of tangible and intangible commitments to foreign markets • Lack of market knowledge is constraining – a barrier to expansion of internationalisation
INV/Born Global McDougall, Shane & Oviatt (1994) Oviatt & McDougall (1994, 1995, 1997, 2005) and others e.g. Knight & Cavusgil (2004)	• Knowledge is an enabling resource • Mobility of knowledge allows for more rapid internationalisation, knowledge is easily deployed to a new country • Highlights knowledge intensity and technical knowledge • Imprinting effect – long term effect on org. learning capabilities. Knowledge is a moderating factor.
Network approach Johanson & Mattsson (1984, 1988), Welch & Welch (1993),Welch, Welch, Wilkinson & Young (1996, 1998), Coviello (2006), Coviello & Munro (1995,1997) Osarenkhoe (2008)	• Networks can be an enabler or a barrier to access market knowledge valid for firms following either PTI or INV • Firms embedded in local networks – learning from others

Source: Summarised from Chapter 2

A review of the literature on the key drivers of growth for high-technology new ventures has also shown that knowledge plays an important role in both innovation and internationalisation (see tables 4.2 and 4.4). It is also noted that the knowledge required is likely to be predominantly outwith the firm's boundaries (e.g., Fernhaber & McDougall-Covin, 2009). In addition, Zahra et al. (2000), McNaughton (2001) and Kuemerle (2002) have shown that internationalisation is associated with deeper technological learning and

general organisational learning (Yli-Renko et al., 2002; Brennan & Garvey, 2009). Thus, internationalisation enhances the technological innovation of the firm. It has also been shown that knowledge-intensive high-technology firms have a broader scope of internationalisation and a more rapid pace (McNaughton, 2001, 2003).

The other key stream of literature for SME growth is that of entrepreneurship (see table 4.3 for a review). A review of the entrepreneurship literature places great emphasis on the prior knowledge of the entrepreneur to enable opportunity recognition. The need to combine different types of knowledge is also highlighted, suggesting that additional knowledge is required to exploit entrepreneurial opportunities. External knowledge sourcing is an important strategic activity, given the levels of continual innovation required in knowledge intensive sectors such as the life science industry, but little is known about the sourcing of knowledge by HTNVs. Many questions relating to the leverage of knowledge in HTNVs remain unanswered.

Table 4.3 A review of literature – Entrepreneurship and the role of knowledge

Entrepreneurship theory	**The role of knowledge**
Shane & Venkataraman (2000), Lumpkin & Lichtenstein (2005), Corbett (2007), Marvel & Lumpin (2007)	Opportunity recognition is a knowledge-based process, which requires new knowledge to be mixed with existing knowledge in order for new insights to be gained Types of knowledge: ways to serve markets, customer problems, markets and technology.
Roberts(1991),Venkataraman (1997), Shane (2000)	Prior knowledge (incl. market & technological knowledge) is required for opportunity recognition). Knowledge is dispersed and specific to individuals based on experience
Penrose (1959), Zahra & Filatochev (2004), Liao et al (2006)	Opportunity exploitation is underpinned by managerial ability to utilize knowledge
Ucbasaran, Westhead & Wright (2008)	Different types of knowledge are required to successfully exploit an opportunity
Macpherson & Holt (2007)	Entrepreneurs play a key role in creating a context in which knowledge and learning is valued, to maintain the entrepreneurial culture
McGrath (1999), Minniti & Bygrave (2001)	Entrepreneurs gain knowledge from both successes and failures
Zahra et al. (1999), Kazanjian et al. (2001) Ireland et al. (2001)	Knowledge management is central to Corporate Entrepreneurship. Creating value from new knowledge generated requires management of knowledge processes.

Source: Summarised from literature review in table 2.4 in Chapter 2

The exploration of knowledge processes between opportunity recognition and exploitation through, for example, the launching of new products and services, including the temporal aspect of these processes, would make a valuable contribution to knowledge and the purpose of this thesis is to contribute to filling that gap.

Table 4.4 A review of literature - the role of knowledge in innovation

Innovation scholars	**The role of knowledge**
Drucker (1993)	In the fast pace of technological and scientifically based innovation in high-technology firms, knowledge utilization needs to be as intentional, methodical and effective as the utilization of any other resources.
Calantone et al. (2002)	who argue that since the innovation process involves the acquisition, dissemination and use of new knowledge, a learning orientation is an important antecedent of firm innovativeness
Saedmundson (2005)	New fields of technical knowledge provide new opportunities for growth. Interaction between growth and the development of technical knowledge is likely to result in an increase in the number of technological fields during growth.
Liebeskind et al. (1996), Al-Laham & Amburgey (2005), Dierickx & Cool (1989), Powell et al. (1996)	The ability to exploit external knowledge is a critical component of innovative capabilities. External sourcing of knowledge is an attractive and frequently used alternative, especially in fast-paced industries. Crucial knowledge often lies beyond firm boundaries, requiring firms to tap into external knowledge to develop and maintain their competitive advantage
Kodama (1986), Pavitt et al.(1989), Grandstand & Sjölander (1990), Oskarsson (1993) Grandstrand (1998), Patel & Pavitt (1998), Leonard–Barton (1995)	Technological innovation is multidisciplinary due to scientific advances. Firms need to be able to integrate new technologies with existing technologies to sustain a competitive position Most innovation occurs at the boundaries between specialist domains
e.g., Iansiti (1993), Leonard & Sensiper (1998), O'Connor & Veryzer (2001), Christensen & Petersen (1990)	The importance of both technology and market knowledge as prerequisites to recognising opportunities (Christensen & Petersen, 1990)
Renko et al. (2005)	Marketing orientation literature - Successful innovation requires understanding and invention, both on the technology and the market sides(:234)
Palmberg (2004)	Market knowledge such as customer demand, market niches and collaboration with customers, environmental issues, regulations and standards were just as important sources of innovation. a firm has to assimilate more than just the scientific knowledge for the successful commercialization of an innovation (Palmberg, 2004)
Carlile (2004)	Managing knowledge across boundaries in an organization is what creates competitive advantage
Helfat (1994), Nelson (1982), Nelson & Winter (1982)	Firms tend to search for new technical knowledge in areas which allows them to build on their established knowledge and resource base
Chesbrough (2003)	Open and external models of innovation, firms seek innovations developed out-with the firm
Madhok (2007)	Knowledge sourcing is a more critical organizational activity than the exploitation of currently held knowledge in dynamic environments characterised by rapid technological change
Carayannopoulos & Auster (2010)	External knowledge sourcing as an important strategic activity, particularly in knowledge intensive industries
Cohen & Levinthal (1989), Lane et al. (2006)	The importance of absorptive capacity to enable the firm to utilise knowledge from out-with the firm

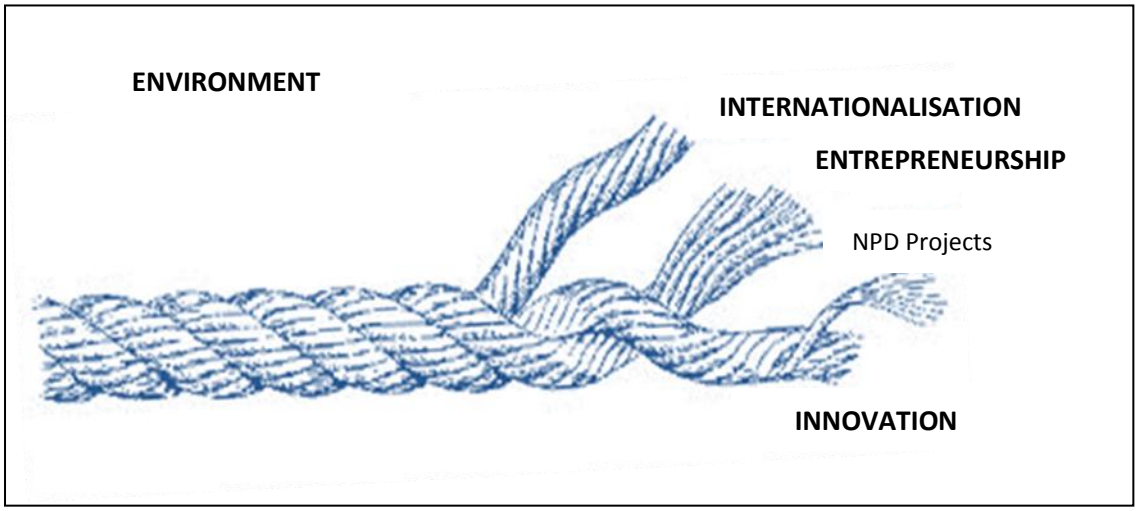
Source: Summarised from Chapter 2

4.3 A holistic approach to key integrated entrepreneurial processes in HTNVs and the role of knowledge.

Despite the increasing number of studies focusing on SMEs operating in high-tech markets (Crick & Jones, 2000; Gassman & Kuepp, 2007), more holistic work needs to be done examining the interdependent processes that contribute to the growth and development of HTNVs (Onetti et al., 2010). The theoretical stance of this thesis takes a holistic perspective, examining the sample for evidence of the interwoven nature of the three key drivers of growth in HTNVs.

This study takes a holistic approach to *key integrated entrepreneurial processes* in HTNVs. In Figure 4.2 the complex interwoven relationship between the key drivers of growth in HTNVs is represented by the rope diagram. Each of the three strands of the rope represents one of the key drivers of firm growth, entrepreneurship, innovation, and internationalisation, all of which the firm must manage and move forward simultaneously for the firm to grow.

Figure 4.2 A holistic approach to key integrated entrepreneurial processes



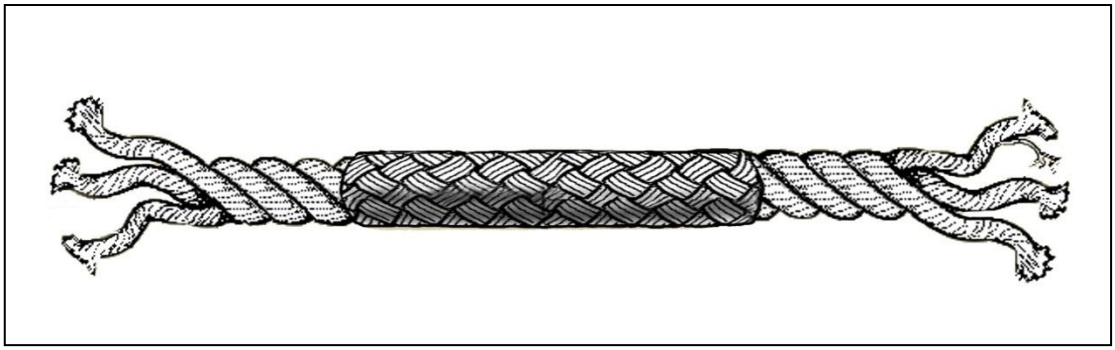
Source: Developed by researcher, drawn from the literature review in Chapter 2

Within each strand, there are multiple sub-elements represented by the yarns, and within these there individual fibres which represent specific projects such as specific new product development projects, all of which have particular knowledge associated with them. The

review of the literature in these three areas (see tables 4.2 – 4.4) would suggest that the knowledge is intertwined with all of the firm's activities. In the same way as a rope loses its strength and ability to perform a task if individual strands become detached or frayed, the management of HTNVs must maintain all strands of their activity in order maintain progress of the firm towards its growth objectives.

The illustration of the role of knowledge in a holistic approach to key integrated entrepreneurial processes takes inspiration from modern ropes used in sailing yachts (see Figure 4.3), where the inner core which provides most of the strength for the rope to perform its task, is enhanced and supported by a protective mantle which protects the core, preventing it from becoming frayed, and determines the handling properties of the rope (how easy it is to hold, to tie knots in, and so on), thus maximising the performance of the inner core. In the same way, the knowledge processes within the firm support the key drivers of growth and maximise the performance of the firm.

Figure 4.3 The role of knowledge in key integrated entrepreneurial processes



Source: Developed by the researcher, drawn from the literature review in Chapter 2

As a sailor needs to keep ropes in good order so that they can be used as required, so too does the management team of an HTNV need to ensure that the firm's knowledge processes are flexible to adjust with the needs of key integrated entrepreneurial processes to maximise the benefits from these three strands that drive firm growth. Although there has been significant study of HTNVs, there have been few holistic studies examining how the knowledge processes within the firm support the key drivers of growth. Therefore, this study makes a contribution to a fuller understanding of how knowledge processes contribute to the growth of HTNVs.

As these firms have limited knowledge resources within the firm, they depend on external knowledge to enhance their competitive advantage, and growth potential. Key to growth is the absorption of external knowledge and the ability to apply that new knowledge to provide solutions to the growth challenges the firm faces.

4.4 Why are critical events important for the growth of small firms?

All stages of growth models have been shown to be unrepresentative when tested empirically (e.g., Phelps, Adams & Bessant, 2007). (See section 2.9 for a summary of the literature). However, it has been shown that before firms grow, they tend to have to navigate through a period of time or 'states' where they have to deal with challenges associated with barriers to growth, in order to make the transition into a period of growth (Kazanjian, 1988). These have been called points of crisis (Greiner, 1972; Churchill & Lewis, 1983), critical events or tipping points (Gladwell, 2000) in the literature. Critical events have associated growth challenges which have to be surmounted in order for the firm to grow. As these growth challenges or hurdles are surmounted, the problem resolution involves organisational learning and the synthesis of new knowledge which adds to the stock of knowledge within the firm (e.g., Deakins et al., 2000; Clarysse & Moray, 2004; Wright et al., 2007). (See Table 4.5 for a summary of the relevant literature).

In order to navigate beyond the growth challenge, the firm needs the capability to identify any new knowledge it requires, identify the source(s) of that knowledge and acquire it quickly and cost effectively. The new knowledge then has to be assimilated into the firm, disseminated to appropriate departments of the firm and applied to resolve the challenges being faced. Although Miles and Snow's (1978) problem-search-resolution process has been criticised for being simplistic, Kazanjian (1988) argues that if the solution that has been found as a result of organisational learning is disseminated appropriately, future growth of HTNVs can be faster. Kazanjian also suggest that the way in which a firm responds to a 'crisis' event shapes the organisational routines and structure and impacts the future growth of the firm. In particular, the speed at which solutions can be found to challenges at critical events impacts upon growth outcomes.

Table 4.5 Resolution of growth challenges at critical events creates new knowledge

Author	Findings/Theories
Nickerson & Zenger (2004)	Managers should choose what valuable problems to solve, which, if successfully solved, yield desirable knowledge or capability Nickerson & Zenger (2004:618)
Henderson & Clark, 1990; Fleming & Sorenson (2000, 2004)	Solutions to complex problems represent unique combinations or synthesis of knowledge
Kazanjian (1988), Kazanjian & Drazin (1990)	The transition for growth stage-to-stage is an organizational learning process. The manager's role in navigating through the transition impacts on the speed of growth. Organizational learning occurs if a firm maps the solution to problems onto its organization inn terms of specific functions
Miles and Snow (1978)	Problem-search-resolution process Firms face similar problems in each growth cycle. Making the results of organization learning available to appropriate staff across the organization makes the next growth cycle faster
Zahra & Filatochev (2004)	Strategic flexibility of the entrepreneurial threshold firm requires a high degree or organizational learning
Phelps, Adams & Bessant (2007)	"To navigate beyond the 'tipping point' the firm must have the capability to identify, acquire and apply new knowledge to resolve new challenges and succeed in the competitive environment" Phelps, Adams & Bessant (2007:8) The firm needs to become aware of the key issues it is facing and will need new knowledge inputs to provide solutions to the problems generated at tipping points Key to growth is the absorption of knowledge and finding solutions that traverse the tipping points.
Clarysse & Moray (2004); Deakins et al. (2000)	When responding to a crisis event, the learning process is often rapid, leading the entrepreneur to seek alternative sources of knowledge missing from the stocks of knowledge with the firm
March (1991)	Knowledge systems are in constant tension – as the firm oscillates between knowledge exploration and knowledge exploitation, knowledge systems in the firm must adapt.

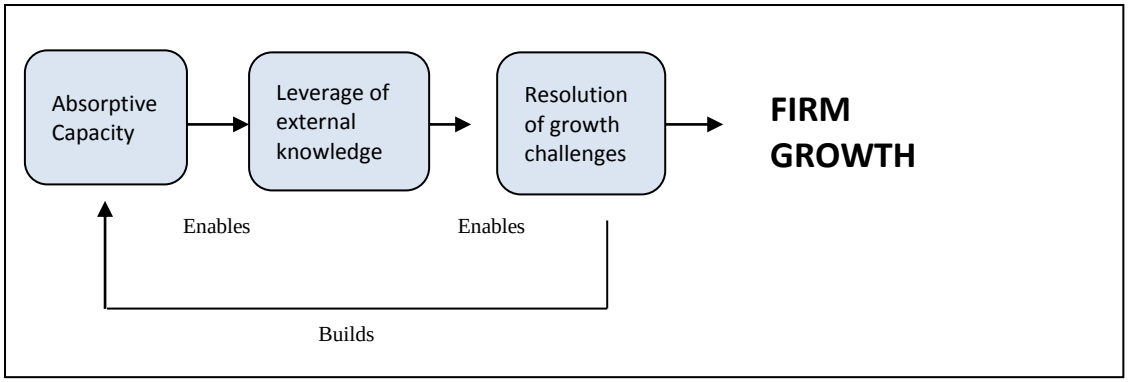
Source: Summarising the literature review in Chapter 2

4.5 Absorptive capacity - a lens to explore the leverage of external knowledge by HTNVs

Macpherson & Holt (2007), in their recent literature review on small firm growth, note that unlike Greiner's (1972) stage model, where internal structures provided solutions to growth problems, in more recent years, firms have been dependent on access to specific knowledge resources outwith the firm to resolve challenges that arise. Although there is significant critique of the stage of growth theories, insights from the development of stages of growth literature point to the importance of assimilation of knowledge and organisational learning to move forward and grow (Macpherson & Holt, 2007; Phelps, Adams & Bessant, 2007). The absorption of external knowledge is critical to finding the solutions to challenges faced by HTNVs as they grow, and enabling the transformation of the firm to optimise their value.

Therefore, the concept of absorptive capacity (ACAP) (Cohen & Levinthal, 1990:128) "the company's capacity to absorb, defined by its ability to identify, assimilate and apply for commercial purposes know-how generated outside itself." ACAP's role in problem resolution was highlighted by Kim (1998:509), making it an appropriate lens to investigate how HTNVs resolve growth challenges by leveraging external knowledge. Figure 4.4 depicts the relationship with ACAP, which enables the leverage of external knowledge by the firm to find solutions to the challenges that they face.

Figure 4.4 Growth challenge resolution and the role of absorptive capacity



Source: Developed by the researcher from the literature review

More recently, Zahra and George (2002b), drawing from the dynamic capabilities view, reconceptualised ACAP as a set of organisational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge. Although ACAP was recognised a process by Zahra and George (2002b), it has been primarily studied as a dynamic capability, missing key process elements that would help develop the concept further (e.g., Easterby-Smith et al., 2008). The literature review of the ACAP concept (Chapter 3) has revealed that it is still a relatively immature construct (Lane et al., 2006) and there are significant gaps in the literature. The review of diverse fields of management literature has also found convergence and overlap in fields such as market orientation, entrepreneurship and knowledge management.

Therefore, this research will contribute to the field of ACAP by taking a process perspective to exploring the processes employed for the leverage of external knowledge to resolve growth challenges. By focusing on the 'how' of the process of knowledge leverage, this study adds significantly to the development of the ACAP theory.

4.6 The research questions

The primary research questions for this thesis are in the context of the life science industry in Scotland:

- *How do HTNVs leverage*[3] *external knowledge at identified critical events to resolve growth challenges they face?*
- *What are the temporal aspects of knowledge leverage by HTNVs at critical events?*

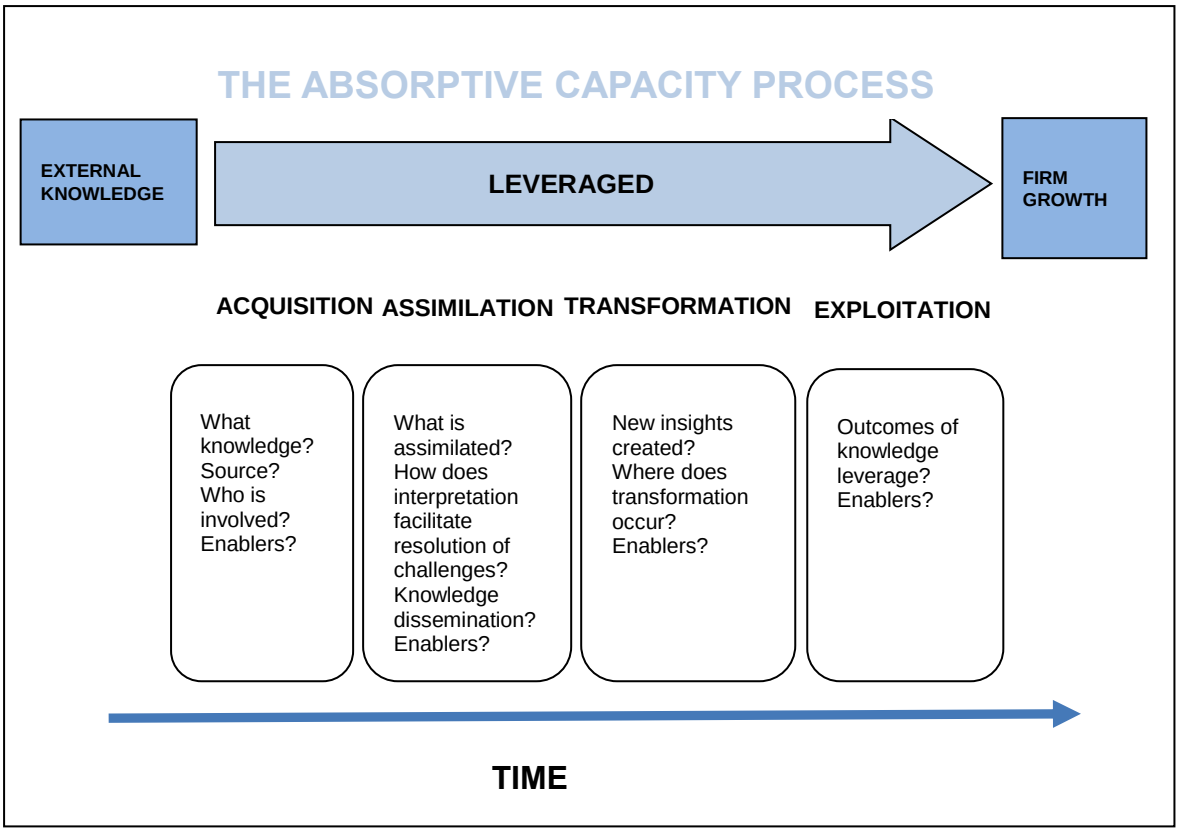
In order to answer these questions, the analytical process is organised following a sequence of logic represented by the following secondary questions:

a) Antecedents- what knowledge, knowledge sources and processes led to this critical event?
b) Event – what was the nature of the event (internationalisation, innovation or entrepreneurship)?
c) What challenges did the firm perceive/respond to at that event?
d) What knowledge facilitated that critical event?
e) Process – what was the process of leverage of knowledge?
f) Outcomes – What knowledge outcomes emerged from this event?
g) Enablers/barriers – what enablers/barriers were effectual?
h) Temporality – what temporal aspects were important for the leverage of knowledge?

Utilising the framework of the dimensions of absorptive capacity (Zahra & George, 2002b), this exploratory study takes a process approach to explore the leverage of external knowledge, and how external knowledge is converted over time through the absorptive process to resolve the challenges faced by HTNVs. The *dimensions of the ACAP process* act as the research lens to examine in depth the processes that occur at each dimension of the ACAP process as the firm leverages external knowledge. There follow a further four sets of questions relating to the dimensions of ACAP (see Figure 4.5).

[3] *Leverage of external knowledge* refers to the utilisation and exploitation of external knowledge to create advantage (e.g., von Krogh et al., 2001; Collins & Hitt, 2006)

Figure 4.5 Conceptualisation of the exploration of the ACAP process



Source: Adapted from Zahra & George (2002b)

The operationalisation of ACAP as a research lens to explore the leverage of knowledge by HTNVs to resolve growth challenges at identified critical events:

Acquisition of knowledge:

- *What knowledge do HTNVs require?*
- *What are the sources of the knowledge they acquire and how do they access it?*
- *What roles are involved in the acquisition of knowledge?*
- *What are the enablers of acquisition of knowledge?*

Assimilation of knowledge:

- *What is assimilated and how does the interpretation of knowledge facilitate the resolution of growth challenges?*
- *How is knowledge disseminated?*

- *What are the enablers of assimilation?*

Transformation of knowledge:

- *How is knowledge combined and what new insights are created?*
- *Where does transformation occur?*
- *What are the enablers of transformation?*

Exploitation of knowledge:

- *What are the outcomes of the exploitation of knowledge?*
- *What are the enablers of exploitation?*

Thirdly, given the short windows of opportunity for HTNVs in dynamic environments:

- *What are the temporal aspects of the leverage of knowledge by HTNVs through the ACAP process?*

Zahra and George (2002b) contend that the temporal aspects of absorptive capacity development need to be recognised in future research, but have been largely ignored to date (Todorova & Durisin, 2007). In this study, the temporal aspects of the absorptive process will be explored, measuring the time taken from the acquisition of external knowledge, through the processes of assimilation and transformation to exploitation.

4.7 Conclusions and implications

This chapter has outlined the conceptualisation of the line of enquiry for this study. It is clear that an understanding of how firms process and assimilate external knowledge they acquire, and how existing and new knowledge is combined, is vital to gain a more holistic understanding of how the firm transitions through growth challenges. This study uses the construct of ACAP as an appropriate lens for the investigation of this phenomenon. The research questions have been articulated, along with the secondary research questions based on the dimensions of ACAP (Zahra & George, 2002b). The next chapter outlines in detail how these research questions are operationalised in the methodology for this research study.

Chapter 5

Research Methodology

5.1 Introduction

This chapter outlines the research methodology used in this thesis to explore the primary research question for this thesis, which is in the context of the life science industry in Scotland:

- *How do HTNVs leverage external knowledge at identified critical events to resolve growth challenges they face?*
- *What are the temporal aspects of knowledge leverage by HTNVs at critical events?*

Using the framework of absorptive capacity (see Figure 4.5), this study explores the routines for the acquisition and assimilation of external knowledge, and how external knowledge is transformed through the absorptive process to create capabilities that exploit that knowledge for competitive advantage and growth.

This chapter begins with a discussion of the research philosophy and approach which underpins the research methodology used. The research design is outlined, including the background to the research, the selection of case study method, data collection and data analysis used. This chapter concludes with a profile of the case study companies that participated in the research. A summary diagram of the research process is presented in Figure 5.1.

5.2 Outline of the research design and approach

This is a processual case study-based project, which focuses on events reported as critical to growth by respondents. Taking a qualitative approach, the primary data collection tool employed to understand the leverage of knowledge to resolve the challenges associated with identified critical events was in-depth semi-structured interviews with senior management in seven HTNVs within the life science industry in Scotland.

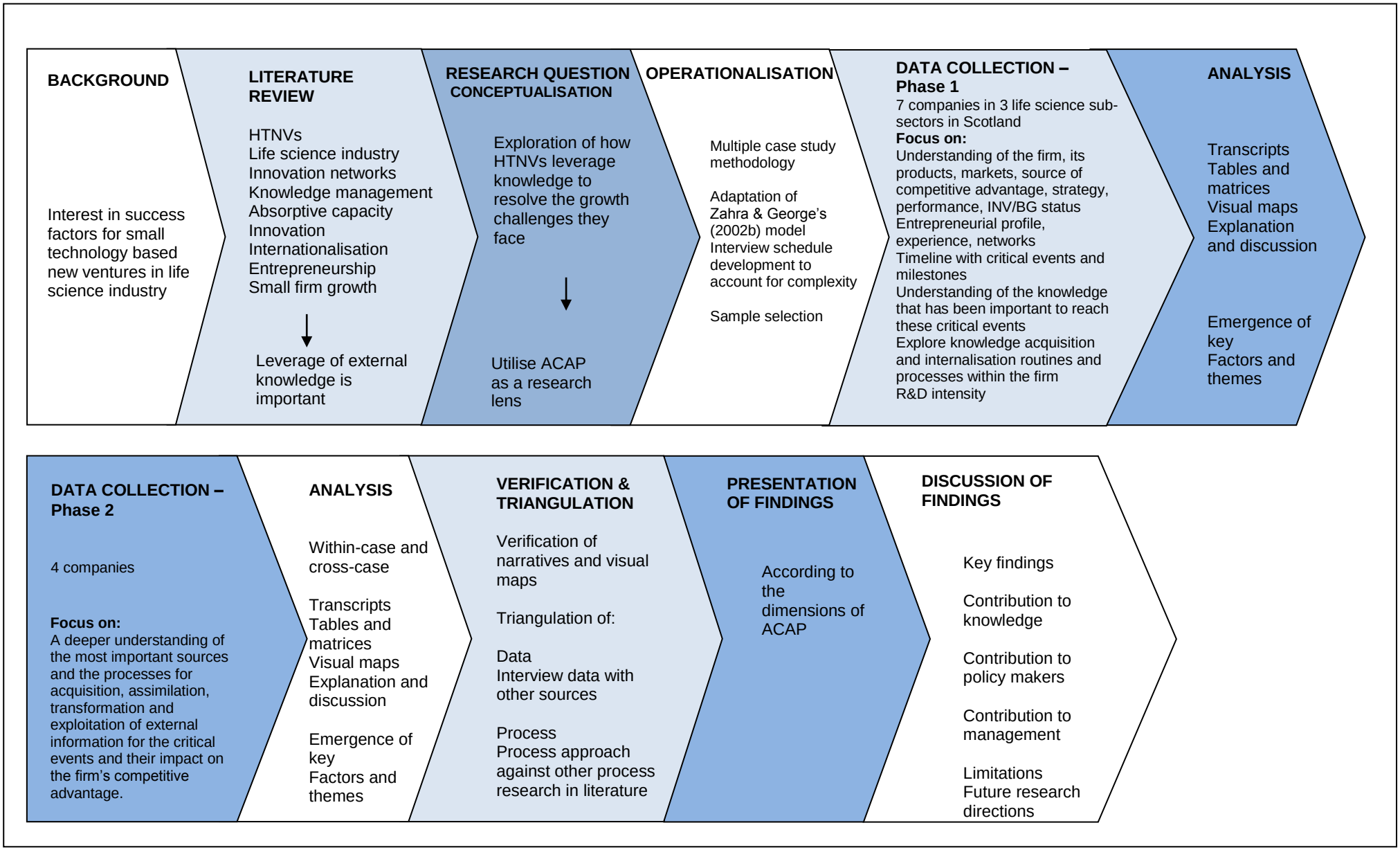


Figure 5.1: A summary of the research process in this study

5.2.1 Research philosophy and approach

This research adopts a qualitative approach to investigate h*ow high-technology new ventures, within the life science industry, leverage external knowledge to resolve growth challenges they face, at identified critical events* whereby the philosophical assumptions are that the phenomena being researched are subjective rather than objective (Easterby-Smith et al., 2002). A key reason for taking a qualitative approach is to take account of the context surrounding the process being observed (Pettigrew, 1992; Yin, 2003).
Qualitative research is defined as

" an array of interpretative techniques which seek to describe, decode, translate and otherwise come to terms with meaning, not frequency of certain more or less natural phenomena in the social world" Van Maanen (1983:9)

This study is based on an interpretivist/phenomenological paradigm which stems from an ontological view that the world and reality are socially constructed and given meaning to by people (Easterby-Smith et al., 2002). This is in contrast to the positivist paradigm which considers that the social world exist externally, is objectively determined thus its properties can be measured objectively (Easterby-Smith et al., 2002). The interpretivist/phenomenological approach is concerned with subjective, qualitative which are content rich (Godfrey & Hill, 1995). A subjective approach focuses on deep meanings and aims to understand what is happening in the totality of each situation (Saunders et al., 2007). See Table 5.1 for a summary of the two paradigms.

Table 5.1 Features of the two main paradigms

Positivist paradigm	*Phenomenological/Interpretivist paradigm*
• Tends to produce quantitative data • Uses large samples • Concerned with hypothesis testing • Data is highly specific and precise • The location is artificial • Reliability is high • Validity is low • Generalises from the sample to the population	• Tends to produce qualitative data • Uses small samples • Concerned with generating theories • Data is rich and subjective • The location is natural • Reliability is low • Validity is high • Generalises from one setting to another

Source: adapted from Hussey & Hussey (1997:54)

An interpretivist paradigm is suitable for this research as it recognises that business situations are complex and unique, as a function of a particular set of circumstances and individuals (Saunders et al., 2007). This is supported by Pettigrew (1992, 1997) who argues that the organisational processes are embedded in context. A further argument to support this choice of approach is that theory is not well developed in this area: Knowledge processes within HTNVs which enable growth of the firm, and in particular the absorptive capacity process, are not well understood (e.g., Lane et al., 2006) and there have been few empirical applications.

The exploration of change in the firm calls for a holistic approach rather than a linear explanation of the process (Pettigrew, 1992). A holistic approach is therefore appropriate for this study which investigates the leverage of external knowledge by HTNVs within the life science industry in Scotland. The research design enables the researcher to answer the 'how' questions as well as the 'what' questions, which would not have been possible with a purely quantitative study. In order to provide powerful insights into the learning processes of firms, an in-depth qualitative approach to data collection was taken, which emphasises the use of rich, non-numerical data or data that have not been quantified (Saunders et al., 2007). A subjective approach to research often involves the use of multiple methods or investigates small samples over time (Easterby-Smith et al., 2002). It can be flexible and allow changes in research emphasis as the research progresses.

The approach adopted by this research is inductive, rather than deductive, and aims to understand the deep meanings of phenomena (Miles & Huberman, 1994). With induction, theory building takes place after the data have been collected, and is concerned with the context in which events take place (Saunders et al., 2007). It involves developing ideas, through induction from the data that are subsequently related to the literature. However, following the approach suggested by Eisenhardt (1989), this research utilises a review of existing literature to ensure that the author is familiar with key areas in the field which enabled the further refinement of the research question with a view to enhancing the potential for a contribution to knowledge.

In summary, this study adopts a qualitative approach based on an interpretivist paradigm, using a process of induction to derive deep insights into the processes that enable the

leverage of external knowledge by HTNVs at critical events. This approach enables new insights to be derived from the data collected, and new theory to be developed.

5.2.2 The role of the researcher

The interpretivist epistemology enables the researcher to adopt an empathetic stance. The approach recognises that the researcher is part of the research process and seeks a subjective insider knowledge of the phenomena (Saunders et al., 2007). Drawing from Steedman's (1991:53) view that 'knowledge cannot be separated from the knower' and that insights from research are subject to interpretation (Van de Ven, 2007), the judgement of the researcher is important to interpret the information as it is being collected and make decisions about a search for additional evidence (Yin, 2003). Taking a reflexive view of this study, as the researcher has 14 years' experience in the life science industry, and is currently working in the Life Sciences Team of the Scottish economic development agency, Scottish Enterprise, she has an excellent understanding of the issues faced by firms in this industry and brings this wealth of experience to this study. As discussed in Chapter 1, the motivation for this project initially came from the researcher developing and managing a networking organisation that helps life science SMEs make the connections they require to assist with their development. Furthermore, the motivation to develop a deeper understanding of the challenges faced by firms and how they leverage external knowledge to resolve these challenges means that this research is grounded in solving real issues facing young and rapidly-growing HTNVs, and aims to offer insights to the management teams of small HTNVs.

The researcher has taken guidance from Yin's (2003:59) suggestions on the skills that a case study investigator should have. Although his case study methodology is based on a positivist/postpositivist approach, these insights can be equally applied to the interpretivist approach:

- The ability to ask good questions and interpret the questions
- Be a good listener, and not be trapped by preconceptions
- Be adaptable and flexible, and spot opportunities through unexpected issues in data collection
- Have a firm grasp of the issues being studied

- Be unbiased by preconceived notions and be sensitive to contradictory evidence

This research also draws on Dawson's (1997) guidance on the importance of the less tangible tacit field work knowledge for a successful completion of a processual case study, such as understanding the timing and appropriateness of questions, maintaining good relations with respondents, understanding the context in which data are collected and maintaining open to competing data. The author's good rapport with respondents and well-developed understanding of the industry drivers and the life science sector in Scotland are therefore a strength, as a high level of industry knowledge enables a much deeper analysis of issues.

Pettigrew (1997:399) states that "openness to possibilities is a key intellectual requirement for the process scholar". During this study, the researcher has been mindful that a strong knowledge of the industry represents a potential risk of bias due to subjective judgement. This risk of bias is controlled through rigorous evidencing of all analysis and synthesis, and ensuring that hypotheses developed are clearly linked to the data (Kaplan, 1964:302; Van de Ven, 2007:127).

5.3 Research Design

5.3.1 Process research

The research conceptualisation phase of this research outlines a requirement to explore the knowledge processes of HTNVs within the context of the life science industry in Scotland. By utilising ACAP (Cohen & Levinthal, 1990) as a framework for the exploration of the leverage of external knowledge by HTNVs, this research also addresses the call of Easterby-Smith et al. (2008) to use a processual approach to further understand the inner processes of ACAP.

The value of processual approaches to understand the dynamics of organisational change gained increasing recognition throughout the 1980's (Van de Ven & Huber, 1990) and highlighted the importance of context in examining unfolding processes of change and the ability to widen interpretation by presenting complex data from multiple sources (Dawson,

1997). Van de Ven and Huber (1990: 213-219) argue that research questions that seek to examine organizational change over time require a framework which can explain the unfolding temporal processes of change. They note two key aspects of processual research: firstly, process studies are fundamental to gaining an appreciation of dynamic organisational life, and to developing and testing theories on organisational adoption, change, innovation and redesign (Van de Ven & Huber, 1990: 213-219). Secondly, process research can be defined as the dynamic study of behaviour in organisations, focusing on organisational context, sequence of incidents, activities, actions which unfold over time (Van de Ven, 1992: 169; Pettigrew, 1992).

This study draws from Pettigrew (1992), who in his review article, summarises five guiding assumptions of the Warwick processual research:

1. embeddedness, studying processes across a number of levels of analysis;
2. temporal interconnectedness, studying processes of the past, present and future time;
3. a role in explanation for context and action;
4. a search for holistic rather than linear explanations of process; and
5. a need to link process analysis to the location and explanation of outcomes.

Pettigrew (1992, 1997) argues that processes are deeply embedded in context and suggests that inner and outer contexts that shape processes should be analysed. Inner contexts, he describes as the inner mosaic of the firm such as the structural, cultural and political environment within the firm. Outer contexts include the economic, social political, competitive and sectoral environments in which the firm is located. These data are collected in first phase of the data collection in this study. This reinforces the importance of the initial part of this study, in which the foundation and history of each case is captured. However, these are only the building blocks, providing a context to aid in the analysis of the leverage of knowledge in the firm through the absorptive capacity process, and searching for underlying mechanisms or routines which drive the process.

There is also recognition of processes being constrained or enhanced and path-dependent on context such as tradition, structure, culture, and technological strategies. Another key element proposed by Pettigrew (1992) is that there are multiple intertwined processes at any given time. Figures 4.2 and 4.3 within the conceptualisation chapter demonstrate the

complex processes that drive growth in HTNVs and the role of the firm's knowledge processes in supporting these drivers. This research explores the growth challenges associated with critical events that have had impacted on the firm's ability to grow, and investigates the leverage of external knowledge required to resolve challenges and transition to the next stage of growth. Pettigrew (1992, 1997) also emphasises the need to establish a link between process and outcome. He argues that it focuses the research by providing an anchor point. The outcome of enhanced competitive advantage, as a result of knowledge acquisition, assimilation and exploitation, is an important aspect of the ACAP theory. Therefore the firms selected for the more in depth second phase of the study were selected specifically due to being interesting cases of the phenomenon (the leverage of knowledge through the ACAP process) being observed as resolution of growth challenges.

Drawing from Pettigrew (1992, 1997), who states that time and history are at the centre of any process analysis, this study is interested in the temporal aspects of the ACAP process. Various researchers have emphasised the benefit of longitudinal observation case studies to study the process of change (Pettigrew, 1992; Van de Ven, 1992, 2007), but this was not possible within the time limits of this study. However, in-depth interviews and critical incident technique are also recommended as part of in-depth case studies which reveal the richness of routines and processes taking place over time (Pettigrew, 1997; Yin, 2003). Exploring patterns in critical events is key to developing a deep understanding of processes (Langley, 1999). Furthermore, event analysis is suggested by Hallbäck and Larimo (2006) for examining the growth of INVs. This research was carried out using a combination of these techniques, over a period of more than 12 months and therefore, although it cannot capture the detail of a real time observation study, it does capture historical data and the changes over that period of time in addition to retrospective accounts. Van de Ven (2007:208) suggests that by using retrospective accounts, there is the 'advantage of the big picture – how things developed and the outcomes that ensued', and that 'post-hoc knowledge is helpful for interpreting the events that unfolded, and for constructing a narrative of the process'. He suggests that this is more holistic than observing processes in real time where events may be missed which later can be viewed as critical. Moreover, due to the potentially significant time lag between initial knowledge acquisition and exploitation by HTNVs, it is not possible to follow the real-time leverage of knowledge within the time frame of a PhD research.

5.3.2 The case study methodology

This study adopts a case study methodology to explore the process of leverage of external knowledge by HTNVs in the life science industry in Scotland. Case study is a research strategy which focuses on understanding the dynamics presents within single settings (Eisenhardt, 1989). The case study is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2003:13). It is particularly recommended in process research (Pettigrew, 1992; Van de Ven, 1992; Langley, 1999) and in exploring and explaining phenomena (Tsoukas, 1989:555), particularly when addressing a process not yet thoroughly researched (Leonard-Barton, 1990). Instead of seeking answers to questions such as "how much" or "how many," case study design is useful for answering "how" and "why" questions (Benbasat et al., 1987; Yin, 2003). In addition, it is useful in gaining insights and for developing hypotheses or propositions for further research. Drawing from Pettigrew (1992), this research takes a holistic approach to key integrated entrepreneurial processes during both within- and cross-case analysis, seeking patterns of explanation to examine the complex phenomenon of the leverage of knowledge by small HTNVs.

Case study methodology not only enriches theory, but the researchers themselves (Voss et al., 2002). By conducting research in the field and being exposed to the real growth challenges that firms are facing, the context of cases, and the processes utilised for the leverage of external knowledge, I have benefited personally from the process of conducting the research, gaining valuable insights can then be applied to future roles within the industry.

5.3.3 Development of the research question for case study research

Mintzberg (1979) highlights the importance of a well-defined research focus which enables the researcher to "collect specific kinds of data systematically." This study draws on Eisenhardt (1989), who argues that the rationale for defining the research question is the same as it is in hypothesis testing research, suggesting that without a strong research focus, it is easy to become overwhelmed by data. Yin (2003) and Pettigrew (1992), taking a

positivist approach, argue that case study research benefits from prior development of theoretical propositions that guide data collection and analysis. However, this study follows Eisenhardt's (1989) approach of using the literature to identify potentially important issues in advance (see section 5.4). In this way, this research uses a review of existing literature to identify the key drivers of growth for HTNVs, to ensure that these drivers are included to provide a holistic study of the phenomenon in question, and allowing the researcher to explore these issues more accurately (Bourgeois & Eisenhardt, 1988). However, as this is an interprevist study, following Eisenhardt's advice, no construct will have a guaranteed place in the resultant theory.

As described in Chapter 4, the primary research questions for this thesis are, in the context of the life science industry in Scotland:

- *How do HTNVs leverage external knowledge at identified critical events to resolve growth challenges they face?*
- *What are the temporal aspects of knowledge leverage by HTNVs at critical events?*

Using the framework of absorptive capacity (Zahra & George, 2002b), this exploratory study takes a process approach to examine the acquisition, assimilation, transformation and exploitation of knowledge. Secondary research questions are outlined in detail in section 4.6 and represented diagrammatically in Figure 4.5.

5.3.4 Measures taken to ensure rigour

One of the major issues in producing high standard qualitative research, especially when case studies are concerned, is to ensure that the research is carried out according to rigorous research criteria. This research seeks to employ good quality case study methodology by following Yin's (2003) recommended tactics for addressing the four established tests on research quality, namely (a) construct validity, (b) internal validity, (c) external validity and (d) reliability. The ways in which this study addresses the application of these tests are outlined below and summarised in table 5.2.

- *Construct validity*

By being specific that the leverage of external knowledge being investigated is related to the development and growth of the firm, and relating the key aspects of the research instrument to the research questions, this study maximises construct validity. Since this is an exploratory study, it has not used the proxy measures of ACAP used in many other studies, which do not give an accurate or full measure of the phenomenon. In addition, the three tactics advocated by Yin (2003) and Van de Ven (2007) of using multiple sources of evidence, establishing a chain of evidence and having key informants review the case study report, were all employed in order to maximise construct validity. Drawing from Van de Ven's (2007:90) advice to use multiple sources of information in order to gather data from different perspectives, multiple respondents were interviewed in the detailed case studies.

- *Internal validity*

The main cause of concern with case studies is that incorrect inferences may be drawn from the evidence that is gathered. This study aims to minimise the risk by careful data analysis. The selection of firms according to a predetermined protocol (see section 5.3.5) ensured that cases were HTNVs, were spread across the subsectors of the life science industry and had a spread of maturity. Explanation building is used to reinforce causal links, which provide further insight into the phenomenon and lead to robust contribution to the field. Yin's (2003) warning of pitfalls in explanation building and the need to constantly refer to the research objectives was heeded as themes emerged from the data and emergent theory was developed.

- *External validity*

External validity, or the extent to which a study's findings are generalisable beyond the case itself, has been a major barrier to case study research (Yin, 2003; Van de Ven, 2007). The interpretivist paradigm raises questions about the generalisability of research that attempts to capture the rich complexity of social situations. However, the interpretivist would argue that generalisability is not of crucial importance when such rich insights are achieved (Saunders et al., 2007). Therefore, although generalisation is not automatic, by conducting cross-case analysis of multiple cases, insights from the findings of this study may be applicable to HTNVs facing similar growth challenges, in similar sub-sectors of the industry or at similar stages of maturity.

Table 5.2 Tactics to achieve quality of case study design

Test	Case study tactic	Research phase
Construct validity	• Use multiple sources of evidence • Establish chain of evidence • Have key informants review the case study report	Data collection Data collection Composition
Internal validity	• Do pattern matching • Do explanation building • Address rival explanations • Use logic models	Data analysis Data analysis Data analysis Data analysis
External validity	• Use theory in single-case studies • Use replication logic in multiple-case studies	Research design Research design
Reliability	• Use case study protocol • Develop case study database	Data collection Data collection

Source: Yin (2003:34) – COSMOS Corporation

- *Reliability*

The object of reliability is to minimise errors and biases (Yin, 2003). This thesis employs the tactics suggested by Yin to maximise reliability and ensure that procedures are documented. This includes the development of a case study protocol, and a case study database. Van de Ven (2007:219) also notes that the significance of incidents may change over time, and the researcher must ensure that the meaning of incidents as coded is consistent with the meaning derived by the participant firms. In this study, the analysis of the key events was reviewed with the participants of detailed case studies in order to ensure that the meanings of events were valid and that there were no events missing or incorrectly described.

5.3.5 Selection of case studies

This study utilises multiple case studies, following advice that although single case studies can richly describe the existence of a phenomenon (Siggelkow, 2007), multiple case studies enable broader exploration of the research question and better theory building Eisenhardt & Graebener (2007). Eisenhardt (1989) states that there is no ideal number of cases, although she recommends that a number between 4 and 10 works well. While fewer than 4 cases makes it difficult to generate theory of any complexity, and the empirical grounding is likely to be unconvincing, with more than 10 cases, Eisenhardt suggests that it quickly becomes difficult to cope with the complexity and volume of data.

In the first phase of this research, 9 case studies were initially selected. All of the HTNVs in the sample of this research had been international in their focus since their inception and therefore can be described as international new ventures or INVs (McDougal & Oviatt, 2000). The sample firms have been selected from firms within the life science industry in Scotland to give a representation of the three main sub-sectors (drug discovery & development, pharmaceutical services and medical technologies). Kazanjian (1988) provides a useful means of categorisation of the HTNVs in order to ensure spread of maturity within the sample. However, the focus is on the transition to the next phase of growth rather than on the Kazanjian stage itself. See table 5.7 for a summary of characteristics of cases within this study. The researcher used her knowledge of the HTNVs in the life science industry in Scotland, through her role Scottish Enterprise, to select suitable firms to approach to take part in the study. Initial contact was made with the founder/CEO by email and a meeting was subsequently organised.

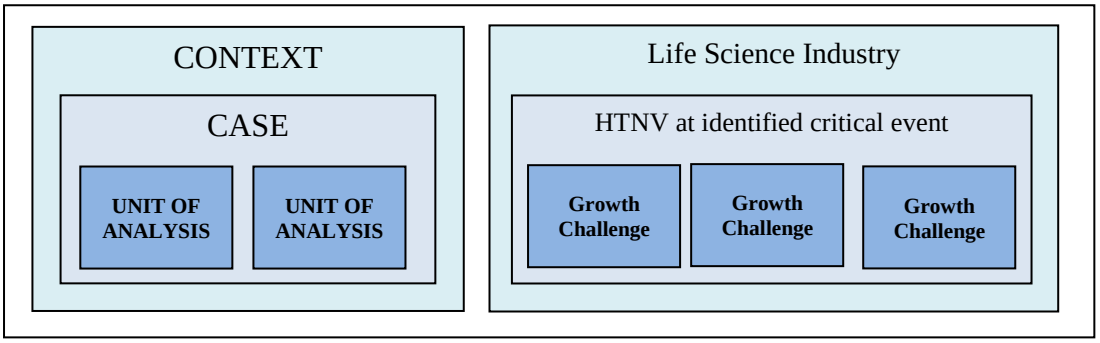
Pilot interviews were conducted with 4 of these 9 cases, of which 2 cases were dropped from the study at this point and 2 were taken forward to the main study. As the first phase of data collection revealed that the leverage of knowledge related to critical events for the firms was a very complex process, it was thought to merit further exploration in a smaller sample. Therefore, the second phase of this research explored in further detail a specific situation in a smaller number of case firms, where external knowledge had been acquired, assimilated, transformed and exploited to resolve growth challenges at identified critical events. The cases for Phase 2 were selected from the remaining sample of 7 firms in Phase 1, and were selected specifically due to being interesting cases of the phenomenon under observation. This type of purposive sampling is recommended for processual research (Pettigrew, 1997) to optimise answering the research question. Four firms were selected from the initial seven cases for more in-depth investigation with multiple respondents. The selection of these cases can also be considered theoretical sampling (Eisenhardt & Graebner, 2007) as they were exemplars of the leverage of external knowledge to resolve growth challenges, chosen for the insights that they would provide and their contribution within a set of case studies. These firms were also selected due to access to multiple respondents within the firm. Furthermore, with the limited time and resources available for doctoral research, it was not possible to conduct multiple interviews across the whole sample.

5.3.6 Unit of analysis

Drawing on Yin (2003), this study employs an embedded design, that is, multiple levels of analysis within a single case. Therefore, within each case in this study, there are embedded units of analysis which reflect the growth challenges that the firm is facing at an identified critical event (see Figure 5.2). The number and type of growth challenges vary in each case depending on the critical event identified by the firm, thus reflecting the nature of case studies that are dependent on the context of that case.

Multiple case studies can create more compelling arguments, but as each case has a different context, this makes generalisation more challenging. However, drawing from Leonard-Barton's (1990) work, by deliberately varying the context and nature of the growth challenges relating to the leverage of external knowledge, this may point to greater potential generalisability of findings. By collecting firm profile data about the characteristics of the firm and the environment in which it operates, this enables patterns in the data to be investigated.

Figure 5.2 Application of embedded units of analysis within case study methodology



Source: Adapted from Yin (2003:40)

5.4 Data collection

Case studies typically combine data collection methods such as archives, interviews, questionnaires and observations, and can combine qualitative and quantitative data (Eisenhardt, 1989; Yin, 2003). Figure 5.3 provides a diagramatic representation of the case study data collection and analysis process used in this research project, including in-depth interviews with key individuals from life science firms, secondary research from

publicly available company information, and general industry publications, and media articles. The triangulation, made possible by multiple data collection methods, provides stronger substantiation of constructs (Eisenhardt, 1989). A number of researchers have highlighted the synergy of using both quantitative and qualitative data. Quantitative evidence can be corroborated and explained by qualitative exploration, but similarly qualitative data can be strengthened by quantitative data. Table 5.3 summarises the data collection in this research study and table 5.4 summarises the data collection from the in-depth interviews.

Table 5.3 Overview of data collection

Venture	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Life science sub-sector	PS	PS	PS	PS	PS	MT	MT	DD	DD
Kazanjian stage	4	3	4	2	3	2	1	3	2
Int model	INV	INV	INV	INV	INV	INV	INV	INV	INV
Interviews with founder(s) (# of interviews)	Yes (4)	Yes (2)	Yes (1)	Yes (2)	Yes (1)	Yes (1)	Yes (2)	Yes (1)	Yes (1)
Interviews with other staff (# of interviews)	Yes (2)	Yes (3)	No	No	No	No	Yes (1)	No	Yes (1)
Follow up emails	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Analysis of company website and marketing materials	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Analysis of press releases and media coverage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Analysis of industry documents and secondary sources	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pilot interviews	Yes	Yes	Yes	No	No	No	No	Yes	No
Phase 1	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Phase 2	Yes	Yes	No	Yes	No	No	No	No	Yes
Life science sub-sector: DD: Drug discovery and development, PS: Pharmaceutical services, MT: Medical Technologies Research phase: Phase I is initial exploratory interviews & Phase 2 is explanatory in-depth multiple interviews.									

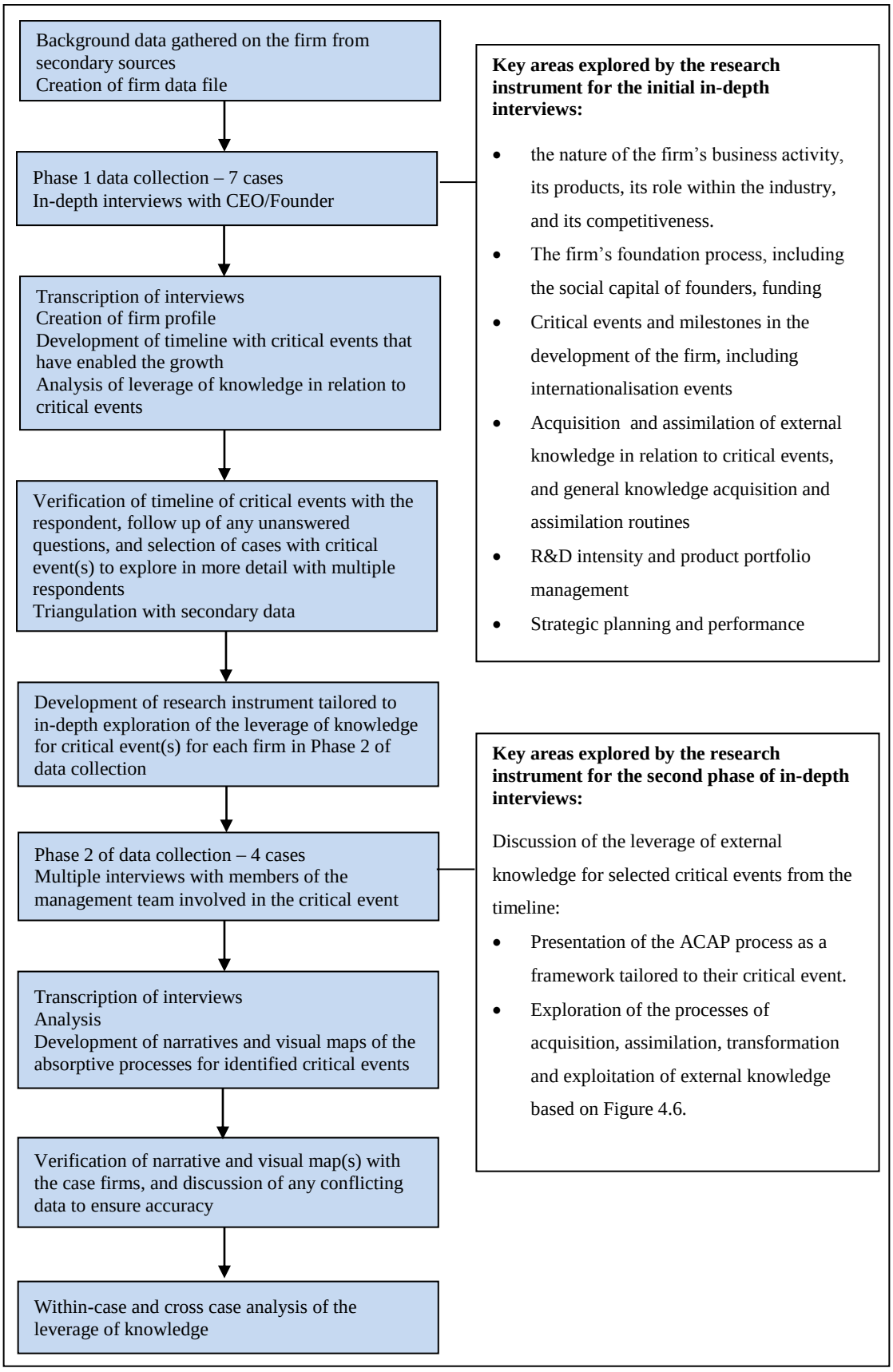
Source: Developed by the researcher

Table 5.4 Interview length and information collected for this study

No of Interviews	Total interview time	Average time per interview	Total no. of transcripted pages	Average no. of transcripted pages per interview
17	18hrs	1hr 4mins	375	22

Source: Developed by the researcher

Figure 5.3 A summary of case study data collection



Source: Developed by the researcher

5.4.1 Background research and development of a case study database

Background research was carried out on each case in advance of in-depth interviews. A database was created for each case. See table 5.5 for an anonymised example of the contents of a case study database. The case database for the appropriate case was consulted prior to each interview in order for the researcher to familiarise herself with the firm's activities.

Table 5.5 The contents of a case database

Contents	Description
Correspondence	Signed letter of consent Emails, directions to the firm
Interview data (Phase 1)	Completed interview schedule Any additional interview notes Electronic interview recordings Transcripts Any diagrams or other explanatory material provided by the firm during the interview
Interview data (Phase 2) if selected	Interview schedule and diagrammatic representation of the absorptive process relating to a particular critical event/growth challenge used as interview aids Interview notes Electronic interview recordings Transcripts
Company marketing material	Brochures and leaflets
Pages from company website	Product and service information, management team expertise, blogs, newsletters downloaded from the company website
Press releases	Announcements relating to company activities including: funding rounds, product launches, expansion, merger, international events attended, quality accreditations achieved.
Secondary data	Case studies conducted by third parties, media articles, industry newsletters
Timelines	Various version of timelines as they were developed and refined through discussion with the firm
Case narratives	Descriptive narratives Visual maps of the absorptive processes discussed by the firm
Analysis diagrams	Diagrams developed during analysis to assist understanding including : knowledge flow, social capital, knowledge sources
Analysis	Within case analysis matrices for knowledge acquisition, assimilation, transformation and exploitation of knowledge

Source: Developed by the researcher

5.4.2 In-depth interviews

In-depth interviews are an important element of the research design of this study, and are the primary data collection tool for this multiple case study. In the interpretivist epistemology, where the objective is to understand the meanings that respondents ascribe to various phenomena (Saunders et al., 2007), in-depth semi-structured interviews provided the researcher with the opportunity to 'probe' and ask respondents being

interviewed to explain or build on their responses. An interview schedule was developed in advance (as described in section 5.6.3) to avoid losing focus and to ensure that all the relevant questions were asked, and in the same order for each case.

- *Pilot in-depth interviews*

Four pilot interviews were conducted in order to evaluate the research instrument. It was determined that the research instrument was indeed effective and should be used for the in-depth interviews. These pilot interviews also highlighted that although one hour had been allowed for each interview, due to the complexity of the issues being discussed it would be difficult to capture all the data required in a single interview of that length. This pilot enabled the research design to be altered to include a second phase of interviews that would enable a deeper understanding of the leverage of knowledge for specific growth challenges in a smaller sample of firms. The researcher also allowed for longer exploratory in-depth interviews for the rest of the cases.

- *Phase 1- Exploratory in-depth interviews*

Phase 1 involved in-depth interviews with the CEOs/founders of seven case study firms, including two of the four pilot interviews where the researcher was able to revisit the firm and complete the interview schedule. Respondents were provided with access to the University of Glasgow's ethical guidelines and their consent was formally noted and included in the case database. A sample of the letter of consent is in Appendix 1. Founders and CEOs were primarily targeted as key informants due to their level of knowledge of the firm and their position as key decision makers. Semi-structured interviews with founders/CEOs of the firm were held at the firm's premises and lasted between one to three hours. As it was important to allow the data to come from the field, the interview schedule consisted of six open questions which were presented on flash cards to the respondents, who were encouraged to express their thoughts on the topic of interest as freely as possible. The open questions were followed by more structured closed questions. The respondent's narratives were recorded and transcribed. In a small number of cases, some information which the CEO did not have readily available was provided at a later date. All interviews were taped and transcribed. CEOs were reassured that the research was

independent, their responses were confidential and that individual comments would not be attributed to firms unless they requested this to be done.

- *Phase 2 – Explanatory in-depth interviews*

Analysis of narratives developed from the first phase of interviews highlighted a number of examples of growth challenges at critical events being resolved. For the second phase of interviews, four cases were selected with interesting examples of external knowledge being acquired, assimilated, transformed and exploited at critical events to enable the firm to resolve challenges. These interviews were carried out to obtain more specific data on the issues that had emerged in the initial interviews. Eisenhardt (1989:538) suggests that this is a legitimate procedure in qualitative theory-building case studies, while the researcher is trying to understand the phenomenon in question in as much depth as possible. The overlap between data analysis and data collection is a clear benefit of this research methodology.

In each case, these interviews probed deeper into the critical events discussed in Phase 1, with an emphasis on the processes and routines for knowledge acquisition, assimilation, transformation and exploitation. In Phase 2, multiple informants from different parts of the organisation were interviewed from each case. This provided a variety of perspectives on a particular situation. Dawson (1997:400), when discussing the benefits of seeking multiple accounts of a change process, notes that "discrepancy between the views of different groups is not problematic, but part of the rich data which is accessible through processual research."

In three cases (E, F & G) where the firm was very small, when critical events were identified in the initial interview, and the respondent had time to continue, it was possible to cover the leverage of knowledge relating to a critical event without having to return for Phase 2 interviews. Therefore, although these cases lack the multiple respondents of the Phase 2 sample, they still provide rich data which contribute to the cross-case analysis. These three cases served as replication sites (Leonard-Barton, 1990) for the four lead cases with multiple respondents.

5.4.3 Developing the research instruments

The operationalisation of the research questions is developed in the research instrument, the schedule for the in-depth semi-structured interviews are as follows:

Interview schedule for Phase 1 in-depth interviews

The development of the interview schedule draws from Yin's (2003) view that in order to effectively explore the leverage of external knowledge, it is essential to have a good understanding of the firm's activities, its structure and the context within which it operates Miles and Huberman (1994) also state that a good case history must trace the flow of events over time. Table 5.6 summarises the development of the key areas of discussion included in the interview schedule for the first phase of interviews. As it was important to allow the data to come from the field, the interview schedule consisted of six open questions. Each section was followed up by a series of structured and semi-structured questions which was intended to help verify the narrative provided in response to the open questions, thus enhancing the validity of the research. It was assumed that members of the management team would not be familiar with the management terminology associated with the dimensions of the ACAP process, so open questions were asked in simple, unambiguous language. A sample Phase1 interview schedule is available in Appendix 2.

The case study approach is interested in the wider context within which the phenomenon occurs and therefore this is a key element of the data collection. In attempting to seek explanations for the similarities or difference in the knowledge processes observed, the contextual data were collected to provide a profile of the characteristics of the firm. In order to establish that cases were good examples of the leverage of external knowledge, the interviews schedule was concerned with determining critical events leading to growth and development of the firm, and establishing for each case a timeline of external knowledge being acquired and assimilated within the firm, and capturing the resulting exploitation and growth outcome. Thus, having highlighted a critical event which enabled the firm to move to a period of growth, the schedule then directed the respondent to describe the knowledge processes related to that event.

Table 5.6 The development of the research instrument for Phase 1 interviews

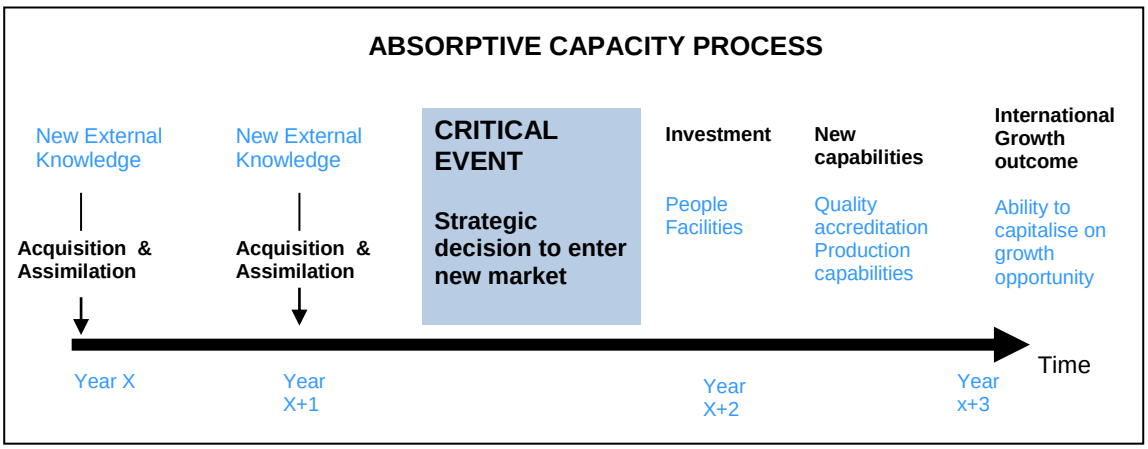
Interview questions relating to:	**Research question**	**Existing theory that shaped the questions**
SECTION A The nature of the firm's business activity, itsproducts, its role within the industry, and its competitiveness. Firm Age and Internationalisation profile at Interview, level of innovation.	Characteristics of the firm (the context within which the firm operates, which affects the primary research question.)	Process research is embedded in context (Pettigrew, 1992) Contextual factors impact on the phenomenon (Tsoukas,1989) Absorptive capacity is linked to an outcome that enhances competitive advantage (Zahra & George, 2002) Uniqueness/Immitability of resources (Teece et al., 1997) (Durand & Vaara, 2009; Newbert, 2007, 2008) Establishing INV status (Oviatt & McDougall,1994:49) Level of innovation (Nelson & Winter, 1982) Context - Reference to the external environment is essential to understand the effect of dynamic capabilities on competitive advantage and performance (Vergne & Durand (2011:374)
SECTION B The firm's foundation process, including the human and social capital of founders, funding.	Background information (The context for the study – which affect the firm's absorptive capacity)	Experiential knowledge (Becker 1964; Shane, 2000) From absorptive capacity literature, The firm's ability to leverage knowledge has been determined by the TMT's experiential knowledge (Cohen & Levinthal, 1990). TMT's international experience (Reuber & Fischer, 1997) Connections and networks (Coviello,2006)
SECTION C Critical events and milestones in the development of the firm, including internationalisation events.	What growth challenges are firms facing at an identified critical event? (The embedded unit of analysis for this study)	Critical event analysis - Hallbäck and Larimo (2006) Miles and Huberman (1994) Points of crisis (Greiner, 1972; Churchill & Lewis, 1983 Responding to crisis shapes organizational routines and shapes future growth (Kazanjian,1988, Kazanjian & Drazin1990)
SECTION D Acquisition and assimilation of external knowledge in relation to critical events. What type of knowledge? Where did the firm source that knowledge? Social capital/networks that were involved? Who is normally responsible for acquiring knowledge? How is knowledge disseminated?	The firm's processes in relation to leverage of external knowledge Knowledge requirements Knowledge acquisition General knowledge acquisition and assimilation routines in place within the firm	Problem resolution involved the creation of new knowledge (Clarysse & Moray, 2004, Wright et al., 2007) Different types of knowledge are needed to exploit an opportunity (Marvel & Lumpkin 2007) Zahra & George (2002b), open innovation (Chesborough, 2003; Lichtenstein & Brush, (2001), networking approach to internationalisation (Coviello, 2006; Coviello & Munro, 1995, 1997) Social integration mechanisms (Zahra & George, 2002b)
SECTION E R&D intensity and product portfolio management. International connections in relation to R&D.	Verification of HTNV status A proxy measure of absorptive capacity	Internationalisation/deeper technological learning (McNaughton, 2001) Yli Renko et al. (2002), Brennan & Garvey (2009)
SECTION F Strategic planning and performance.	Evaluating the firm's growth - Outcomes from the leverage of knowledge	Processual studies should be linked to outcome (Pettigrew, 1992)

Source: Developed by the researcher

Interview schedule for Phase 2 in-depth interviews

The research instrument for the second phase of this research developed a simplified ACAP process model based on the conceptualisation model in Figure 4.6 and was tailored in each case to the critical event in question. See Figure 5.4 for an anonymised example of an interview aid used in Phase 2 interviews. These diagrams focused the attention of the respondent on the critical event being investigated. Any antecedents and outcomes of the process outlined in the first phase of the data collection were included and reviewed with respondents. As the researcher interviewed additional members of staff, the picture of the knowledge processes was enhanced, building and understanding of the knowledge required, how it was sourced and acquired, and assimilated. The combining of knowledge in the transformation step was discussed, together with the investment the firm has to commit in order to realise the potential opportunity. The outcomes of the process, including the development of capabilities, stocks of knowledge and the growth of the firm, were also discussed.

Figure 5.4: Example of an interview aid for Phase 2 data collection



Source: Developed by the researcher

5.4.4 Triangulation

As recommended by many researchers, this study uses multiple sources of data to improve the validity of case study research (e.g., Yin, 2003; Saunders et al., 2007). Triangulation can be used to strengthen a study by combining methods or using several kinds of data (Patton, 2002). This research used multiple sources of data allowing data triangulation

(Denzin, 1978; Yin, 2003), which helps to address concerns regarding subjective judgements by the researcher during the data collection process (Yin, 2003).

Corroboration of the interviews through the use of other sources of secondary data were used to validate the interview data (Yin, 2003). These included 3 main sources of data. First, public sources of information gathered from company websites, national media and other publications were used to verify the information provided by the firm. Secondly, employment data provided by each firm was verified with employment data held by Scottish Enterprise. Thirdly, publicly-available industry reports were used to support industry environment issues raised by the firm. This enhanced the validity of the research through corroboration and cross-checking, and provided a more holistic portrait of the phenomenon within the firm (Ghauri & Grønhaug, 2002). These secondary sources of data are summarised in tables 5.3 and 5.5.

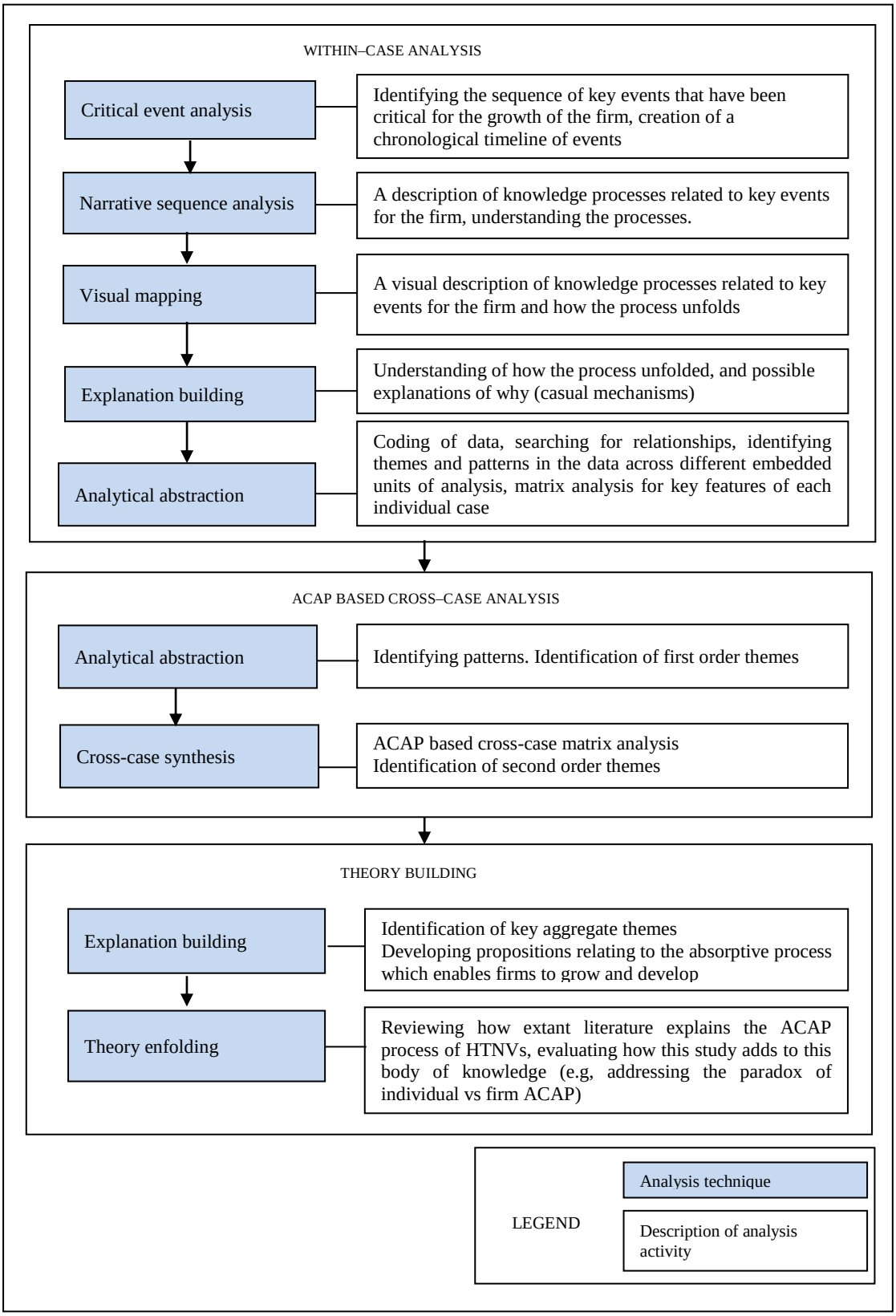
5.5 Analysis

This section describes the analysis conducted in this research. There are two parts to the analysis of this thesis. Firstly, there is exploratory analysis, which involves identifying the sequence of events (Langley, 1999). This is followed by explanatory analysis, which is concerned with understanding how processes evolved over time and why they evolved in that way (Van de Ven & Huber, 1990; Pettigrew, 1992). These are described in the following pages.

5.5.1. Analysis strategies

As described in the research conceptualisation section of Chapter 4 and section 5.2, this study follows an inductive approach. This study draws guidance from Dawson (1997:403) who states "processual analysis centres on decoupling, classifying and recombining data to develop, redefine and create concepts, which enable the presentation of new accounts (post-analytical descriptions), which explain the dynamic process by which change unfolds". Langley (1999) suggests that taking account of context in process research inevitably leads to multiple levels of analysis which are sometimes difficult to separate from each other. She describes the challenge of process analysis as: "moving from

Figure 5.5 Analysis and theory-building strategies used in this study



Source: Developed by the researcher

shapeless data spaghetti towards some kind of theoretical understanding that does not betray the richness, dynamism and complexity of the data but that is understandable and potentially useful to others" (Langley (1999:894). Langley (1999:696) provides an excellent literature summary of seven strategies for sense-making analysis in process research, describing the data requirements for each in terms of depth and breadth, and describes how each strategy favours different types of process understanding.

The untangling of this study's spaghetti is represented diagrammatically in Figure 5.5. The analysis in this processual research study uses a combination of the narrative strategy and visual mapping, along with both within-case and cross-case analysis methods, as recommended by Yin (2003) and Miles and Huberman (1994). This combination of analytical methods appropriately captures the complexity of the phenomenon.

Many researchers advocate overlap between data collection, coding and analysis (Eisenhardt, 1989; Glaser and Strauss, 1967), suggesting that this overlapping of data collection and analysis gives researchers a head start in analysis, but also allows them to take advantage of flexible data collection. In this research, Phase 1 interviews were transcribed and analysed very soon after the interviews. The ability to include some additional specific questions in later interviews enabled the researcher to explore fully the interesting results from early interviews.

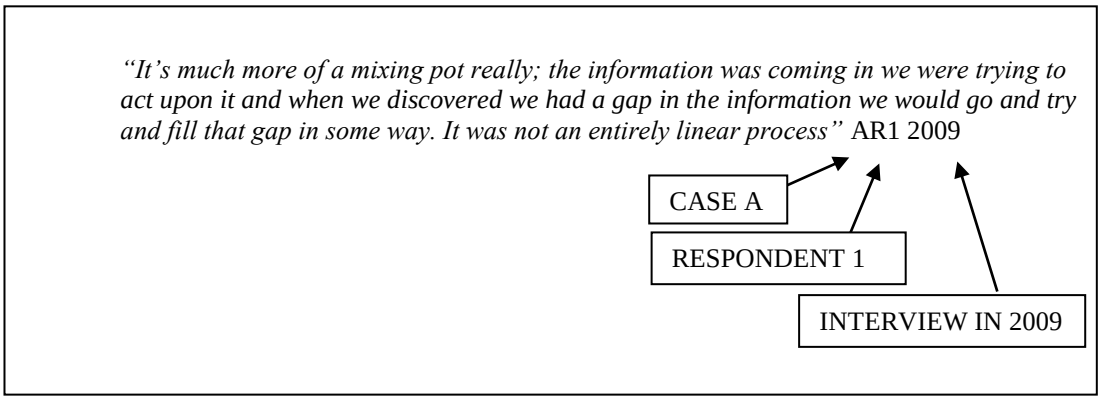
- *Narrative sequence analysis*

Although the narrative can be the main product of process research for those who adopt a constructivist perspective (Dyer and Wilkins, 1991; Guba and Lincoln, 1994), in this study it is a preliminary step which provides a chronology for each case that is used in subsequent analysis to clarify sequences, establish themes and causal links as recommended by Pettigrew (1990). Process explanations that draw on narrative data are particularly close to the phenomenon they purport to explain (Pentland, 1999:712). Furthermore, it is also used as a validation tool which is presented back to the company to verify interpretations of interviews, as recommended by Eisenhardt (1989). The temporal element plays a central role in the narratives as sequences of events build to the outcome. For each case, the sequence of events pertinent to the ACAP process, associated with the

identified critical event, were documented as completely as possible, as suggested by Langley (1999:692). Langley (1999) recommends that this approach is used for a small number of cases due to the richness of the contextual detail.

Used in conjunction with timelines of key events developed for each firm, the chronology of events provides an explanation of the sequence (Pentland, 1999) of the knowledge processes being investigated. The narratives include detailed descriptions of the knowledge processes relating to embedded units of analysis - the critical events that enabled the firm to transition to the next stage of its growth and development. Quotations from the respondents interviewed are included in the narratives, coded in order to ensure grounding in the data, as illustrated on the following page:

Text Box 5.1: Quotation referencing



The 'critical incident technique' is advocated by many researchers (e.g., Stiegelbauer et al., 1982; Keaveney, 1995) as being a good method of evaluating a process which has occurred over time. However, Easterby-Smith et al. (2002) expresses concern that respondents tend to rationalise past actions, and suggests that the use of multiple respondents helps mitigate this problem. In Phase 2 of this research multiple respondents in 4 cases were interviewed, which enabled the researcher to understand the leverage of knowledge for the resolution of growth challenges from the different perspectives of those involved. The selection of the respondents was dependent on the involvement of those individuals with the phenomenon being investigated. In addition, access to company websites and press releases is also a way of verifying the chronological order of events (see tables 5.3 and 5.4).

- *Visual mapping analysis*

This technique is used in conjunction with the development of the process narratives and has the advantage that large quantities of information can be presented in relatively little space (Langley, 1999; Miles and Huberman, 1994). The visual representation allows simultaneous representation of a large number of dimensions, including parallel processes and the passage of time (Langley, 1999). The visual maps for each growth challenge at the critical event highlighted key aspects of process at each dimension of ACAP: the external knowledge acquired, by whom, the source, how it was assimilated, what was interpreted, how the knowledge was transformed and the outcome of the process.

This step links the raw data to further analysis. Looking at such maps, both across different growth challenges within cases and across cases, helps identify common sequences of events and assists with exploration and coding of case narratives and development of themes. Using these two descriptive methods is just the start of the analysis process, which enables identification of sequential patterns, antecedents and consequences (Abbott, 1990; Buttriss & Wilkinson, 2006). Furthermore, by evaluating contextual data, environmental triggers and enablers can be identified. Attention to the detail of the events at this stage of analysis enhances the reliability of the constructs drawn out by further analysis. A selection of visual maps for the leverage of external knowledge by cases in this research are located within Chapters 6 and 7.

- *Analytical abstraction*

The analysis then followed a process of analytical abstraction (Carney,1990), as recommended by Miles and Huberman (1994), during which information was condensed, clustered and sorted which enabled first order themes to emerge. Analysis of structured and semi-structured questions consisted of sorting and presenting the data in arrays and matrices. Transcripts of the open questions were coded manually using open coding and categorised to highlight the salient points as recommended by Yin (2003), and then presented using matrices. A number of the responses to closed questions were used as case characteristics which facilitated further cross-case analysis, such as such as firm social capital, pre-founding and initial founding resources including human capital and previous

internationalisation experience, R&D intensity, level of internationalisation. This process allows the unique patterns of each case to emerge prior to an attempt to find patterns across cases. In addition, this rigorous interrogation of the transcripts provided the researcher with a rich familiarity with each case which, in turn, accelerates cross-case comparison. During analysis, different types of knowledge identified were categorised. The researcher also judged whether the knowledge acquired was tacit or explicit. This was done based on the literature and using the author's knowledge of the industry.

Chapter 6 presents an example of within-case analysis using these three techniques in a single case. Similar narratives with related timelines, visual maps and matrices were developed for all cases, but this empirical richness could not all be presented in full due partly to commercial sensitivity of the data and parsimony required for a PhD submission. Addressing this challenge, this study follows Eidenhardt and Graebner's (2007) advice in using extensive tables to evidence the depth and detail of empirical grounding, as the key findings from within-case analysis are taken forward and presented within the cross-case analysis.

- *Absorptive capacity based cross-case analysis*

The within-case data was categorised and presented in content-analytic summary tables (Miles & Huberman 1994:183), initially for single cases and then displayed as meta-matrices for display of data from several case in a standard form. As this thesis is concerned with understanding how HTNVs leverage knowledge to resolve challenges at critical events, the cross-case analysis initially explores patterns in the nature of the critical events and their associated growth challenges. In keeping with the ACAP lens, the meta matrices created for the cross-case analysis (Miles & Huberman, 1994) focuses on the processes occurring at the dimensions of ACAP: acquisition, assimilation, transformation and exploitation. This analysis condensed the data further and alongside the earlier narratives and visual maps, began the transformation process from describing to explaining the leverage of knowledge by HTNVs. Themes and patterns are identified and presented across groups. The findings from the cross-case analysis are presented in Chapter 7. The cross-case analysis process yielded a set of second-order themes which were taken forward to the theory building process.

5.5.2 Theory building

- *Explanation building*

The objective of the explanation building is to develop propositions which describe causal links (the 'how' and 'why') of a given phenomenon (Glaser & Strauss, 1967), which for this study is understanding how growth challenges are resolved at critical events for HTNVs through the leverage of knowledge, how the ACAP process occurs at each dimension, and the impact of enablers. Explanation building in this study involved an iterative process of taking the key themes that emerged from cross-case comparison of evidence, developing initial theoretical statements (Yin, 2003), reviewing these statements against the facts of individual cases and adapting statements over a number of iterations.

- *Enfolding literature*

Although this is an inductive research study, a key element of building theory from this work is enfolding the theory that exists in the field with the findings in order to enhance the study's theoretical contribution (Eisenhardt, 1989). Through an ongoing iterative process of explanation, building from cross-case comparison and the confrontation with relevant extant literature, propositions are reviewed in order to further develop the field's understanding of the phenomenon. The enfolding of extant literature into the findings from cross-case analysis is discussed in Chapter 8. However, aspects of the enfolding process which led to the development of *a new process model of ACAP* deserve particular attention:

Comparison of visual maps and ACAP-based cross-case analysis with the existing models of ACAP suggests that they do not provide the complete picture of the process. In attempting to explain it more fully, a new model of the ACAP process is developed. Following Whetten's (1989) advice to depict more complex relationships graphically, a model is developed in Figure 8.1. Drawing on Poole and Van de Ven (1989:569) who advocate the constructive use of paradox as a theory building resource, this study uses this technique to build elements of the model. Entrepreneurship theory suggests that the recognition of the value of knowledge is down to individuals, whereas the innovation

researchers suggest that innovation is a collective act. The evidence from this study would suggest that the two perspectives are valid, and that the key element that enables the firm to benefit from the absorptive capacity of individuals is effective communication between key individuals who are gatekeepers of knowledge and the rest of the management team who need to resolve growth challenges. The development of better defined individual- and firm-level ACAP is built into the model.

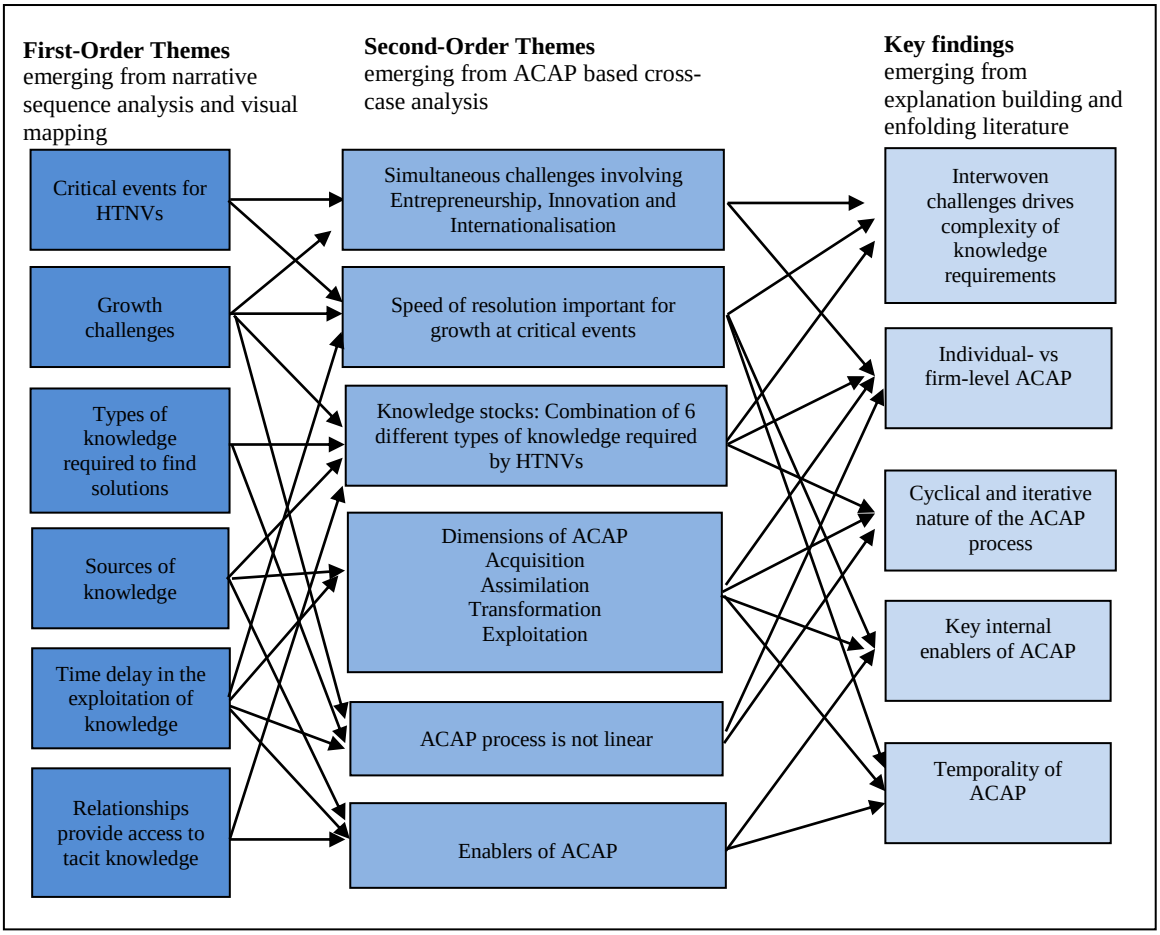
This study highlights that knowledge acquired by individuals must be integrated into the firm's knowledge stocks in order for that knowledge can be exploited. A review of existing ACAP models suggests that this is not adequately explained. The model depicts the relationship between the dimensions of the ACAP process and organisational stocks of knowledge, emphasising the reciprocal relationship between the development of ACAP and stocks of knowledge.

Furthermore, the findings highlighted the cumulative, cyclical and iterative nature of the ACAP process which had not been highlighted adequately by previous models of ACAP. Therefore, the addition of a feedback loop to a new ACAP model adds significantly to the field's understanding of how HTNVs leverage knowledge to resolve challenges.

5.5.3 Summary of analysis outputs

Section 5.7 describes the analysis strategies used in this study. Figure 5.6 illustrates the refining of themes as the research progressed through higher levels of abstraction (Miles & Huberman, 1994). First-order themes emerge from the narrative sequence analysis, visual mapping and analytical abstraction used in within-case analysis; Second-order themes emerge from the ACAP based cross case analysis, which are then developed further in the theory building process and discussed in Chapter 8.

Figure 5.6 Summary of outputs of levels of analysis utilised to develop key findings



Source: Developed by researcher

5.6 Profiles of case studies

All cases in this study are small HTNVs operating within the life science industry and based in Scotland. Due to the high technological input to their products and services, the R&D intensity of these firms is high. Drawing from early proxy measures of the absorptive capacity concept, one would expect these firms to have strong ACAP. Therefore, this is a particularly interesting industry to use as a research setting for the investigation of how firms leverage external knowledge.

Characteristics of the firms are identified which may be helpful in explaining some of the findings. Key case characteristics are summarised in table 5.7.

Case A is a manufacturer and supplier of specialist reagents to a number of parts of the life science industry value chain, from research groups to pharmaceutical and biotechnology companies. The firm was founded by a team with significant experience in the industry and at the time of interview employed 20 FTEs. 88% of the firm's revenue comes from international markets.

Case B is a supplier of specialist CRO services to pharmaceutical and biotechnology firms. The firm was spun out of a local university. At the time of the first interview, it employed 12 FTEs with significant plans for expansion. 80% of the firm's revenue comes from international markets.

Case C is a supplier of contract research services to the pharmaceutical and biotechnology industry. Firm C was spun out of academia and employed 45 FTEs at the time of interview. 70% of revenue comes from international markets.

Case D is a supplier of specialist high value research consumables to the pharmaceutical and biotechnology industries. This firm was founded by a team with significant experience in this sector. 70% of this firm's customers are in international markets, and the majority of the firm's suppliers are also outwith the UK. At the time of the first interview, case D employed two people.

Case E is a supplier of specialist safety testing services to manufacturers of biological therapeutics and vaccines. This firm has had an international focus from inception with 100% of revenue coming from multiple geographies. The firm was founded by an experienced team with many years of prior experience in this sector. At the time of interview, Case E employed 23 FTEs.

Case F is a developer of consumer diagnostic products. Case F was pre-revenue at the time of interview, but anticipated that 80% of revenues would come from international markets. This firm has been international in focus from inception but requires regulatory approval in each geographical market it enters and is currently awaiting approval in certain markets. At the time of interview, case F employed 7 people.

Case G is a developer of diagnostic assays aimed at the animal health market. The firm was spun out of a local university and maintains close links with key research groups. This firm was pre-revenue at the time of interview but anticipated that 70% of review would come from international markets. Case G employed 3 FTEs at the time of interview.

Case H is a drug discovery and development company with a number of drug candidates in development aimed at a number of markets including anti-infectives. At the time of interview this firm employed 16 FTEs, with significant plans for expansion. Case H is currently pre-revenue but anticipates that 80% of revenues will come from international markets. The firm has raised significant VC funding.

Case I is a drug development company with a number of products in development. This firm was pre-revenue at the time of interview, but anticipated that the 100% of revenue will come from international markets. The firm's lead product is currently awaiting FDA approval. This firm operates a virtual development model, outsourcing significant parts of the development to partners. At the time of interview this firm employed 3 FTEs.

Table 5.7 Summary of characteristics of cases selected for this study

Case	Business	Major Product or Service	Size (FTEs)	Foundation Date	No. of Founders	Age at 1st Int'view	Rev/Pre Rev (% Int Rev at int'view)*	R&D Intensity **	Innovativeness of Major Product	Adaptation req'd for Int mrkts ***	Product Portfolio
A	Pharmaceutical services	Supply of specialist laboratory reagents	20	1989	3	19	Rev (88%)	High	Leading edge innovation	No	Yes
B	Pharmaceutical services	CRO/ biological testing services	12	2002	2	6	Rev (80%)	High	Instrument is leading edge, services are incremental	No	Yes
C	Pharmaceutical services	CRO/ biological services	45	1994	2	14	Rev (70%)	High	80% leading edge innovation	No	Yes
D	Pharmaceutical services	Supply of specialist laboratory consumables	2	2007	2	1	Rev (70%)	Low at present but will be high	Incremental innovation	No	Yes
E	Pharmaceutical services	CRO/biological safety testing services	23	2007	7	2	Rev (100%)	High	Leading edge innovation	No	Yes
F	Medical Technologies	Consumer medical device	7	2007	3	1	Pre Rev (80%)	High - outsourced	Leading edge innovation	No	Yes
G	Medical Technologies	Animal health diagnostic assay	3	2007	1	2	Pre Rev (70% exp'd)	High	Leading edge innovation	No	Yes
H	Drug discovery & Development	Drug discovery	16	2000	2	7	Pre Rev (80% exp'd)	High	Leading edge innovation	No	Yes
I	Drug discovery & Development	Drug development	3	2005	2	5	Pre Rev (100% exp'd)	High - outsourced	Incremental innovation	No	Yes

* Rev/Pre Rev= Revenue generating/Pre-Revenue, % Int Rev = % of revenue is generated in international markets. Pre-revenue firms were asked to predict their future international revenue as a % of total revenues

** R&D Intensity is estimated based on the % of staff involved in R&D

*** Adaptation of products required for international markets is a measure of the homogeneity of markets

Source: Summary of case firm characteristics developed from analysis of Phase I of the data collection.

5.7 Summary of research methodology

This chapter describes the research methodology selected in this study utilised to explore the leverage of external knowledge by HTNVs within the life science industry in Scotland, with a particular emphasis on acquisition and assimilation of external knowledge and the impact that has on the development and maintenance of competitive advantage. The methodological approach used is summarised in table 5.8 below.

As this phenomenon is not well understood, this study takes an interpretivist stance, enabling the exploration of the phenomenon within the context of the key events that have impacted on the growth of the firm. Therefore another key reason for taking a qualitative approach is to take account of the context surrounding the process being observed (Pettigrew, 1992; Yin, 1994). Furthermore, this approach is recommended for the study of processes (Pettigrew, 1992).

Table 5.8: A summary of research methods used in this study

Paradigm	Interpretivist
Approach	Qualitative Subjective Inductive Processual
Data collection methods	Case studies with critical events as embedded units of analysis Multiple sources of evidence provide data triangulation: • Interviews with CEOs and other key TMT • Company data, company website and marketing materials • Public sources of information, national media
Analysis	Narrative sequence analysis Timelines with critical event analysis Visual mapping strategy analysis Analytical abstraction ACAP-based cross-case analysis
Theory building	Explanation building Theory enfolding

Source: Developed by the researcher

The research uses a qualitative approach based on multiple case studies of high technology new ventures within the life science industry in Scotland. The development of the case studies involved in-depth interviews with CEOs of life science firms in Scotland, and other key informants and that data was triangulated with other information. Data was coded and content analysis was performed to identify themes, trends and patterns both within each

case and across the cases within this study. Propositions were developed from these themes, enabling theory building. These methods support the inductive approach. This chapter concludes with profiles of the participating case study companies. The next chapter presents the findings of the research.

Chapter 6

Within-case findings

6.1 Introduction

This chapter presents the within-case findings obtained through the analytical procedures described in the methodology chapter. As process research is concerned with understanding how things evolve over time (Van de Ven & Huber, 1990, Pettigrew, 1992), this chapter presents a narrative which resulted from exploratory analysis of one case as an example of how the analysis process unfolded.

Firstly, the critical event identified by the firm is outlined along with the knowledge antecedent that precipitated that event. Secondly, the growth challenges associated with the event are defined. The knowledge processes associated with the resolution of growth challenges are explored using the absorptive capacity framework in order to understand how the firm leveraged external knowledge to enable the growth of the firm. Lastly, enablers and barriers to the leverage of knowledge for this case are identified.

6.2 The profile of Case A

Case A is a manufacturer and supplier of specialist reagents across the life science industry value chain, from research groups, to pharmaceutical and biotechnology companies. The firm was founded in 1989 by a team of 4 individuals with significant experience in the industry and has been operating profitably for 19 years. The Company has been continually recognised as amongst the fastest growing hi-tech companies in Scotland by the Deloitte & Touche Technology Fast 50 programme, and has won three UK Government Department of Trade & Industry SMART (Small firms Merit Award for Research and Technology) awards. At the time of the exploratory interview, the firm employed 20 FTEs. The firm has operated internationally since inception, with 88% of the firm's revenue coming from international markets, and therefore the firm can be classed as an international new venture (Oviatt & McDougall, 1994). This case study was developed from the analysis of six interviews which were carried out with 4 members of the management team at this firm.

Table 6.1 Interview length and information collected for Case A

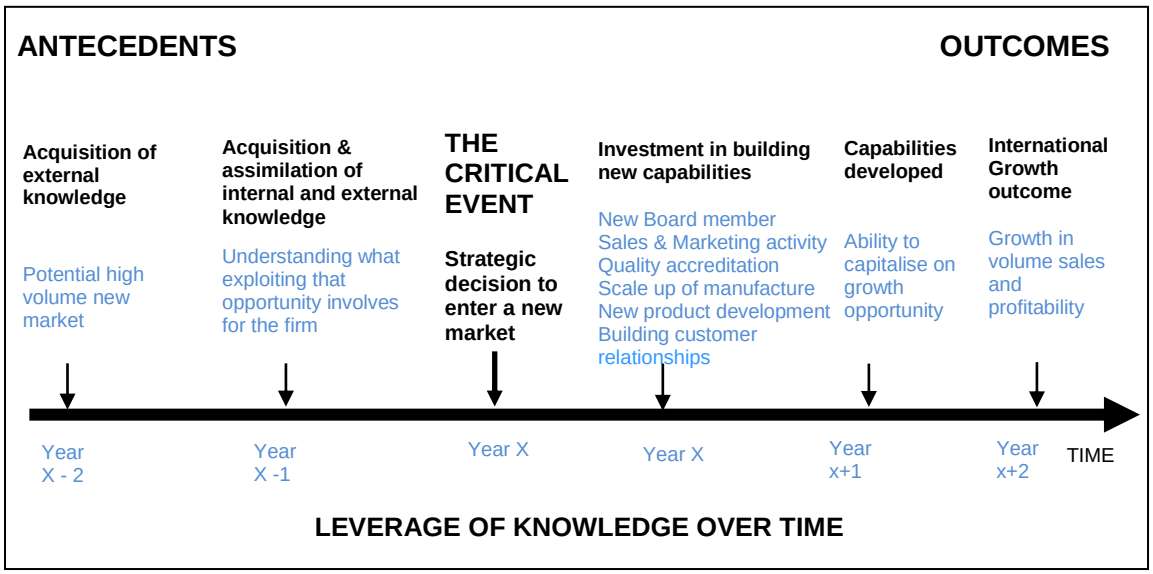
No of Interviews	Total interview time	Average time per interview	Total no. of transcripted pages	Average no. of transcripted pages per interview
6	285 minutes	48 minutes	92	15.33

Source: Developed by the researcher

6.3 The critical event

This case looks at the leverage of knowledge over a four-year period between 2005 and 2009, related to a critical event identified by firm A, the decision to enter a new global niche market, which has enabled the firm to transition to the next stage of growth and profitability. The timeline of this critical event, its antecedents and outcomes is displayed in Figure 6.1. Having evaluated the opportunity, the firm made the decision to invest in scaling up production facilities and in achieving ISO accreditation. The outcome of building this capability is evident in sales growth in the new market and greater profitability for the firm.

Figure 6.1: Timeline of the critical event for Case A



Source: Developed by the researcher from analysis of the exploratory interview

6.4 Growth challenges associated with this event

The firm perceived a number of growth challenges in order to be able to exploit new opportunities in the identified new market; these are summarised in Box 6.1. The assimilation of market knowledge enabled the firm to understand that there were two distinct barriers to entry that had to be overcome in order to enable the firm to be considered as a supplier to that market. Firstly, in a highly regulated industry, Firm A had to be ISO accredited; and secondly, the firm had to scale up its production in order to supply the volumes of product that market would require. Once these barriers had been addressed, the firm then had the challenge of building relationships with potential customers in order to win contracts. Furthermore, due to the power relationships within the industry value chain, the reagents to be used in the process are not specified by the manufacturers of the drug that are Firm A's potential volume customers. The manufacturing process is specified at an earlier stage of development by pharmaceutical and biotechnology companies. Therefore, new product development intended for this market had to be done in partnership with players earlier in the value chain.

Text Box 6.1 Summary of growth challenges associated with critical event

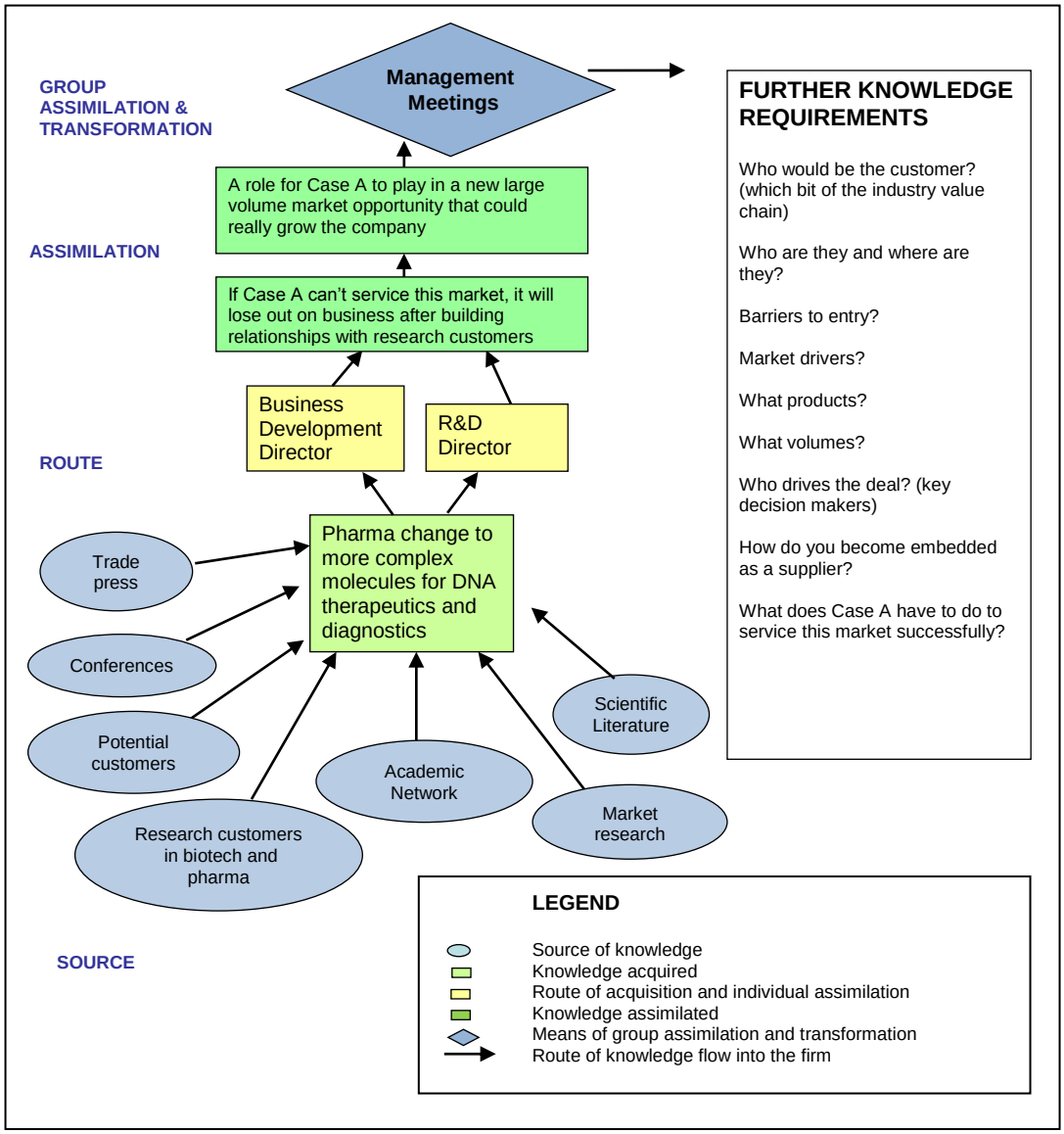
1. Being able to produce the volumes required to service this market.
2. Bringing production processes to the required quality standard to achieve ISO accreditation.
3. New product development for this market, influencing the decision makers earlier in the value chain that specify the inputs to the process.
4. Building and cementing relationships with potential customers in this market, who are located in multiple geographies.

The growth challenges associated within this critical event for Firm A involve the three key drivers of small firm growth (innovation, internationalisation and entrepreneurship), and demonstrate that the firm had to manage all three simultaneously in order to successfully enter this market and to contribute to the growth of the firm.

6.5 Knowledge antecedents to the critical event

The main trigger for this critical event for the Case A was the recognition that there was a change in the trend within the pharmaceutical industry of using simple molecules for the manufacture of DNA therapeutics, to an interest in utilising more complex molecules. Figure 6.2 illustrates the absorption of external market knowledge from a variety of sources for the initial evaluation of the new market opportunity, which led the firm to believe there might be a role for them to play in a new volume market opportunity. During

Figure 6.2: Leverage of knowledge for new market opportunity



Source: Created by researcher based on analysis of interview transcripts

the exploratory interview, the Business Development Director discussed the acquisition of knowledge which enabled the firm to recognise this business opportunity:

> *"Some of the triggers were statements made by companies themselves at conferences. That's another place that we get information, by attending the meeting that take place in this area. One of the things that was a real trigger...There used to be a perceived dogma that what you did was kept your molecule simple. Keep the molecule simple and it will be cheaper to manufacture, easier to manufacture, low cost meant better products, easier to make, higher margins etc. There was a time when there was a distinct change in that message that was coming across."* AR1 2008/24

This firm routinely acquires market knowledge about the changing industry environment through regular interaction with networks of contacts across the whole spectrum of the industry at conferences, and by conducting market research. Firm A was selling small volumes of complex reagents to research customers, and therefore recognised an important change in the market when pharmaceutical and biotech companies involved in drug development started becoming interested in utilising these products.

> *"What's more important was a good activity of the molecule and designing the molecule to have the maximum efficacy, so that it is a more powerful molecule that you need less of. So, it doesn't matter how much it costs. It may cost more, but if it is much more effective, then it's going to be the better molecule. So a second and third generation set of these oligonucletides started to appear that had more complexity and that for us was the signal that we would have a role to play…You were starting to get these speciality things that were added into the molecule."* AR1 2008/25

> *"The people that were really talking* [at conferences] *about the change-taking place were not the researchers. They had always worked with these modified oligos, but what was happening was that some of the people who were looking at drug discovery were saying that we need to modify the oligos to get them to work better."* AR1 2009/1/4

Case A's prior experiential knowledge of operating in the pharmaceutical industry, meant that it was aware that pharmaceutical and biotechnology companies developing DNA therapeutics would outsource the manufacture of these DNA based drugs to specialist GMP manufacturers who would be the volume customers for Case A's reagent products. The firm was already selling reagents to research customers in pharmaceutical and biotech companies. As these developmental drugs were getting closer to clinical trials, the firm also recognised that there was a risk that it would lose out on the volume business if they could not supply the volume GMP manufacturers.

> *"The minute that happened, we thought if it's successful, it was going to have to go through a GMP manufacturer and therefore those would ultimately become our customer if we were going to stay with that product. If we weren't going to kiss goodbye to that product. If we weren't going to just sell into the research market. At that point the knowledge we needed was what were their requirements? What do we have to do in order to be acceptable to them? And basically it was a case of speaking to the GMP manufacturers and saying 'What do you need?'. What do we need to do to become an authorised supplier to xxx[customer] or whoever?"* AR1 2008/20

The key output of the assimilation of knowledge that enabled the firm to recognise a business opportunity was the requirement for additional knowledge to assist in the evaluation of that market opportunity and its fit with the capabilities of the firm.

6.6 Knowledge processes associated with the resolution of growth challenges faced by the firm during this critical event.

In order to address the requirement for more knowledge about this market opportunity, the firm initially decided to engage with these potential high-volume customers and establish what would be required to service this new market. This knowledge acquisition was led by the Business Development Director, who describes the process of evaluating the opportunity:

> *"It's much more of a mixing pot really. The information was coming in, we were trying to act upon it, and when we discovered we had a gap in the information we would go and try and fill that gap in some way. It was not an entirely linear process"* AR1 2009/1/5

Prior experiential knowledge in the industry meant that he knew who the firm needed to talk to in order to acquire further market knowledge about the barriers to entry and the market drivers. These potential new customers were all in different geographical international markets, including the USA, Korea and Germany.

> *"The pharmaceutical companies are essentially becoming R&D and sales companies rather than manufacturing companies. That's a movement so the GMP companies that's where the big value will come* [for Case A]. *There are 6 of those that are really working with the big fellows." "They are just known. It's such a specialised field; It's such a small group"* AR1 2008/22

> *"We ended up talking to all six of them. There were a couple that we know particularly well and they obviously gave us a lot more information and a lot more time but in the end I talked to all six manufacturers to get the information"* AR1 2009/1/4

This iterative process of knowledge acquisition from potential customers was verified by the Marketing Manager:

> *"I think a lot of what we've done has been quite instinctive. We've got some very specific bits of feedback, xxx* [Business Dev. Dir.] *would tend to speak to one or two people, some key companies, who could give him/us a bit of an insight into the way things were going" "It was very much an ongoing process you know, Bob at company 1 says this and so does Bob at company 2, so I think there's definitely… We've been quite focused on specific deals that might make us a fair amount of money."* AR3 2009/3

The knowledge processes that resulted in the decision to enter this new market are multifaceted and occurred simultaneously. However, due to the complexity of this case, the knowledge processes associated with the resolution of each of the four key growth challenges are analysed separately in order to gain a depth of understanding of the case.

6.6.1 Knowledge processes relating to the challenge of production capability scale-up

It was clear to Case A that if they started supplying these GMP manufacturers, as DNA therapeutics started to be manufactured for larger clinical trials, they would need to be able to supply greater volumes of certain products. Case A had already been considering scaling up production, based on significant evidence from a number of sources. In addition to the knowledge that this potential new market opportunity would require larger volumes, the decision to scale up production capabilities at Firm A was also driven by a combination of internal and external knowledge relating to existing business. Furthermore, through monitoring competitor activity, the firm recognised that there was a gap in the market at a particular scale of production.

> *"There was certainly the market opportunity in that we saw that there weren't many people doing that kind of stuff at anything other than a laboratory scale or a huge scale and we certainly felt that somewhere in between about the kilo lab scale…."* AR4 2009/2

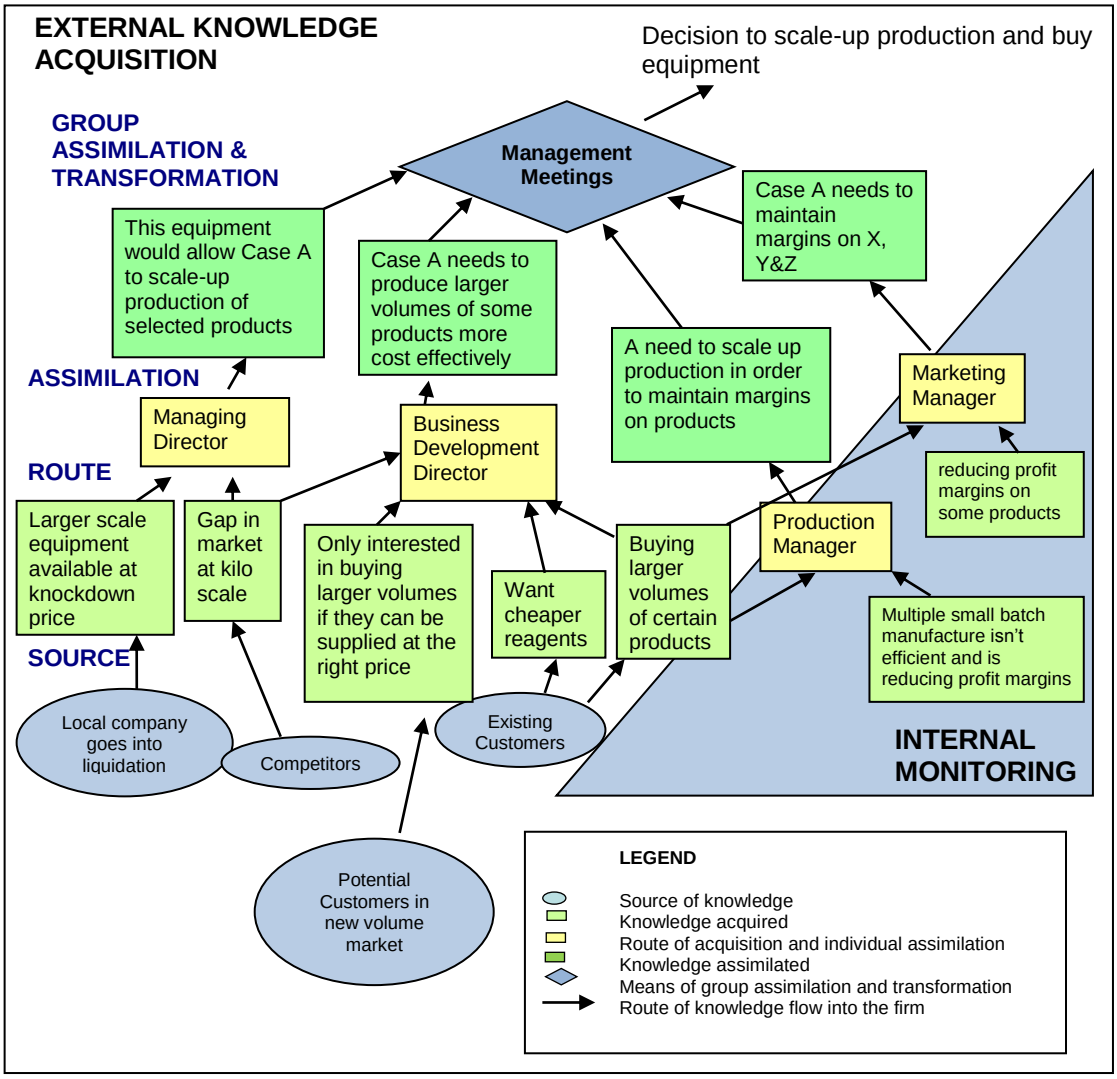
Figure 6.3 highlights that the decision to scale up the production facilities was enabled by a combination of knowledge that came from routine monitoring of both the internal and external environments. External market knowledge from four different sources was acquired and assimilated, and then combined with internal management knowledge gathered by routine monitoring of the profitability of the existing production processes to enable the firm to make a decision.

In addition to the new market opportunity, another key trigger for scaling up production processes was the internal drive to make good profit margins on products, coupled with a drive from existing customers for cheaper reagents, and increased demand for bigger volumes of certain reagents.

> *"We were sure that there was a market for large amounts of some of xxx. It was a case of talking to pharma and to xxx* [customer] *as well, as they were and still are one of our major customers. Quite a lot of the volume was coming through them. So the question was: 'We are selling you quite large amounts of this. Is there anything else that you would benefit from having cheaper?' And you could then sell them much larger quantities. So there was talking to existing customers..."* AR4 2009/8

A team including the Marketing Manager, Production Manager, Business Development Manager and R&D Director is responsible for increasing production efficiency and maximising profitability in the firm. This process was the internal driver for the desire to

Figure 6.3: Knowledge acquisition and assimilation for scale-up decision



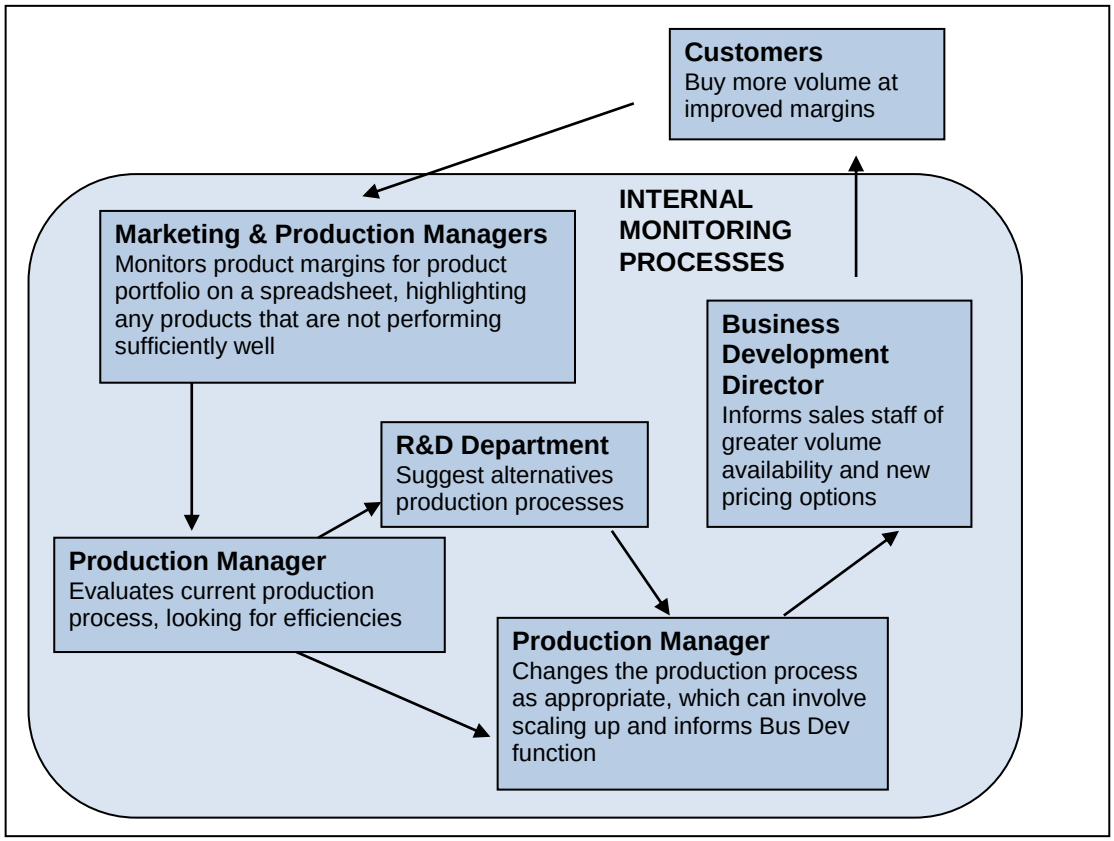
Source: Developed by researcher from analysis of transcripts

Scale up production. The Production Manager explains the process of monitoring profitability:

> *"…we have a cost spreadsheet and it's got the cost and the prices that we offer to the customers and it highlights what our profit margin is. They'll go red if it's less than a certain percentage, so that's the one I am looking at. That's the one we are interested in from production's point of view because I can then say 'Oh gosh, we have a problem here", and then go and speak to the chemists and say 'Can we double the scale of this or what can we do to get that into the green again?'"* AR2 2009/4

Figure 6.4 illustrates the routine internal monitoring that ensures that the firm realises the required profit margin on each product. The knowledge outputs from this routine process led to the recognition that certain products in the portfolio required to be made on a larger scale in order to maintain profitability, but also to be able to offer larger volumes and lower prices to customers facing cost pressures and thus retain these customers.

Figure 6.4: Internal trigger – routine profitability analysis influences scale-up



Source: Created by the researcher developed from analysis of transcripts

> *"We were extremely uncompetitive on a lot of the products so it's a case of moving from 50g to 1kg. Getting information from customer, on a regular basis, would be telling us about the price pressures. For example, that would come through from the sales people"* AR3 2009/1

> *"...as Production Manager, the important information I need to know is are we making enough money on this particular product just now, and if I hear that 'It's too expensive, the salesman cannot sell it just now', then that means I have to look at our process and say 'Right, we need to do something about this'. And taking that to sort of general terms, was one of the big drivers for scaling-up"* AR2 2009/3

The Managing Director discusses the cumulative effect of building knowledge over time, which provides evidence that enables decision making:

> *"This has been hovering in the wings, the scale-up, for quite a number of years. It would certainly have been around, before we moved here, so that would be pre-2000. It is one of these things that various products that you've got come into fashion have grown in sale, and just at the point where you think*

we're going to have to do something about this, then they go out of fashion. So the prospect of doing this has had a few U-turns over the years. But we really were around the point where it was more than just the odd product getting to a large scale. There were three or four that were obviously going to get there, we did need to be able to bring our costs down and improve the efficiency and increase the throughput." AR4 2009/3

"There was also the pressure that some of the products that we were making were getting to large volume anyway, so we had to take a decision, either we scaled them up or we got more people to do more smaller batches of the same things. The other pressure was there is always a constant downward pressure on cost driven by customers unreasonably wanting things cheaper!" AR4 2009/2

The outcome of the knowledge processes was the decision by the firm to scale up its production processes, based on a belief that there would be sufficient volume demand for the firm to achieve the required return on investment. Both the external market knowledge about cost pressures in the industry and internal knowledge about production volumes and efficiency had been building for a number of years, but the decision to scale up was not seriously considered until 2005, when a new market opportunity for volume business arose, which was a 'tipping point' (Gladwell, 2000) for the firm. The Managing Director describes how serendipity also had its part to play in influencing the decision, as a local firm that went into liquidation which provided the opportunity for the firm to purchase the larger-scale equipment it required at a knockdown price.

"…at that point, an opportunity arose of availability of some large scale equipment. It was when xxx[local firm] *went bust. The decision between more chemists and more kit was really I guess helped by the fact that the kit became available, and at what turned out to be a knock-down price. So that kind of pushed us more in that direction. And that was really helped by this perceived lack of people in the market place doing things at that sort of kilo scale. There was research work and a bit of development and there was the large scale manufacture, but not really very much in-between, certainly in Europe."* AR4 2009/3

6.6.2 Knowledge processes in relation to the challenge of quality standards as a barrier to entry

Through building relationships with the 6 potential high volume customers, Case A became aware of the minimum quality standard as a barrier to entry to that market. As manufacturers of drugs for human consumption in a heavily regulated industry, they operate to Good Manufacturing Practice (GMP) standards and therefore their suppliers must operate to a minimum of ISO[4] standard.

"We would talk to them and say 'We have some potential products that we think would be of interest to you'. They looked at our product line and said 'You are probably right, the way things are going. What you need to do is become ISO, you need to set up the necessary systems that we will need'." AR1 2008/21

[4] Explained in Glossary of Terms in Appendix 3

The assimilation of knowledge from potential customers resulted in the decision to implement the ISO quality standard, which was also closely linked to the scale up decision as both would be required to achieve the growth outcome of supplying GMP manufacturers, as described by the Managing Director:

> *"Once we had taken the decision to scale-up, the obvious customers were pharmaceutical and diagnostic manufacturers, and you've got to have ISO as a minimum. As GMP organisations, they are allowed to use ISO."* AR4 2009/4

On top of the ISO requirement, the Quality Assurance (QA) processes of suppliers are also closely monitored and audited by the GMP manufacturers. The assimilation of this knowledge told the firm that the resource implications in monitoring new suppliers meant that a GMP manufacturer would only take on a new supplier of they could not obtain what they needed from their existing suppliers.

> *"They told us what we would need. We went and did it. We go back and say we've now done it. They say: 'OK, we now need to look for the opportunity for a product that you've got that we can't get from an existing supplier'. Again that barrier applies that if they can get it from one of their existing suppliers, they probably will."* AR1 2008/21

Figure 6.5 illustrates the acquisition and assimilation of different types of external knowledge which enabled the decision to implement an ISO quality system. Once the firm understood that this quality standard had to be implemented in order to remove a barrier to entry for this new market, the experiential knowledge of the Managing Director, who is responsible for the quality systems within the firm, and his understanding of quality standards and industry regulations enabled the ISO standard to be achieved rapidly. His knowledge and experience facilitated the evaluation of the changes to ISO quality standard and decide that it was it was now an appropriate time for the firm to become accredited.

> *"When I was in the pharmaceutical industry, I was in the development department and GMP was coming down from manufacturing that you had to start GMP in the development department"* AR4 2009/5

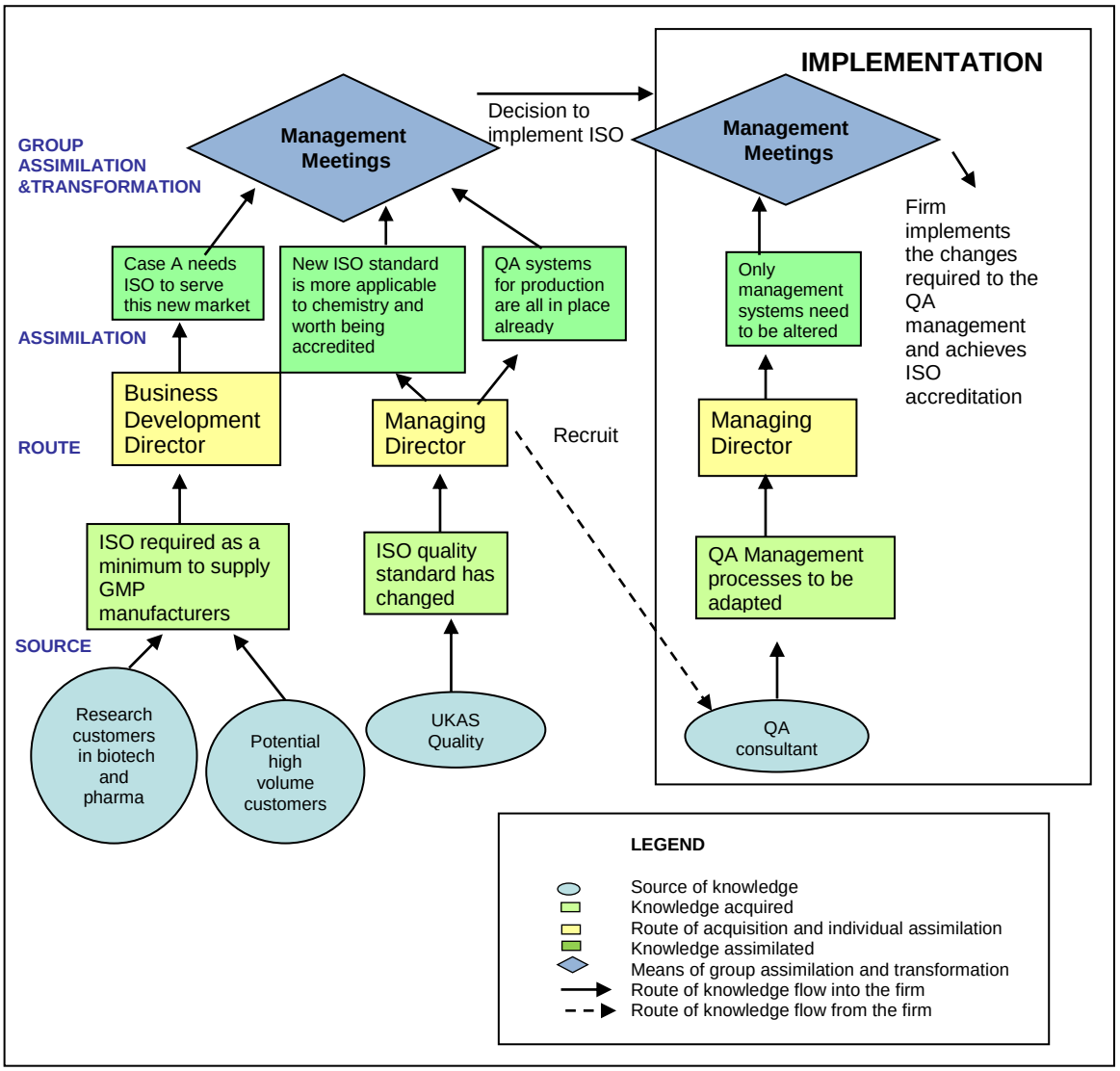
> *"We always resisted ISO before. First of all, because it wasn't necessary and secondly, until relatively recently, the standard really wasn't that applicable to chemistry, it was a paper standard. It was partly understanding the way that the new standard worked. I had been involved in getting something to the old standard and I wasn't impressed. So it was understanding what the standard was. Partly because of my background in the pharmaceutical industry, we'd always built quality systems over and above what we needed to have. It wasn't GMP, but it was a lot of GMP processes, so all the batch record system were there and the QA/QC checks were already there, so it was a matter of filling in the gaps to fit the standard. The bit that really need adding on was really the management processes"* AR4 2009/6

The firm recruited a QA/QC consultant to evaluate the firm's processes and suggest what needed to be done to meet the standard.

> *"We did get some consultancy help as well, just to speed things up. But most of the work was done internally."* AR4 2009/6

"Basically the first thing that happens when you go through that process is that you get a consultant to give you a check. So they basically run through what you have got and say: 'ISO is here, you are there and this is what you have to do'. And most of it is in actual fact just a lot of time so there not a lot of cash involved. There is some consultancy work but mainly with hard graft because we had to alter the systems and you have to write them all down" AR1 2009/1/12

Figure 6.5: Acquisition and assimilation of external knowledge for ISO decision



Source: Created by the researcher from analysis of interview transcripts

The knowledge processes for the resolution of this growth challenge provides evidence for the importance of the combination of internal stocks of knowledge in the understanding of QA standards and examination of current QA processes, combined with external knowledge about quality requirements from customers and potential customers in existing and potential new markets.

The outcome of this ACAP process resulted in the implementation of the changes required to achieve the ISO quality standard, and the removal of the barrier to entry for this global niche market.

6.6.3 Knowledge processes addressing the challenge of new product development for a market where the customers do not specify the product.

In this case, although the customers that will buy the large volumes of reagents from Case A are GMP manufacturers, by the time the drug or diagnostic reaches the stage of development where large scale GMP manufacture is required for clinical trials, the modifiers in the manufacturing process are locked into that process. Firm A realised that new product development for this high-volume market would have to involve working with pharmaceutical and biotech companies earlier in the drug development process.

> *"To take a very specific example which is probably best to illustrate it. There is a molecule, a modifier that is becoming commonly used. It has a problem in using it that these six manufacturers indicated to us was a problem they don't like the molecule that's out there. So, we made another one that solved that problem. We went back to these guys and said 'Here, we've solved that problem' and they said 'well we can't actually change over to the other molecule because these guys* [pharma and biotech] *had already specified the other molecule. So you need to go and tell them about your new molecule and we'll reinforce the message by telling them that if they switch to this molecule. The next time we use an oligo with that modification in it, don't use the old one, use the new one. It will be much better."* AR1 2009/1/5

This case illustrates that for firms in industries such as life sciences with complex value chains, it is essential to have an understanding of the whole value chain in the industry environment as the firm not only has to understand its direct customers, but it is critical to influence other parts of the industry value chain to achieve exploitation of the market opportunity the firm has recognised. Access to market knowledge is very important for this firm, as there is a requirement to keep abreast of developments across the industry, and have a clear understanding of the key decision makers, influencers, and gatekeepers. Therefore, the firm builds relationships with all key actors in order to maximise the opportunity for Case A products to become part of the manufacturing process for new drugs and diagnostics.

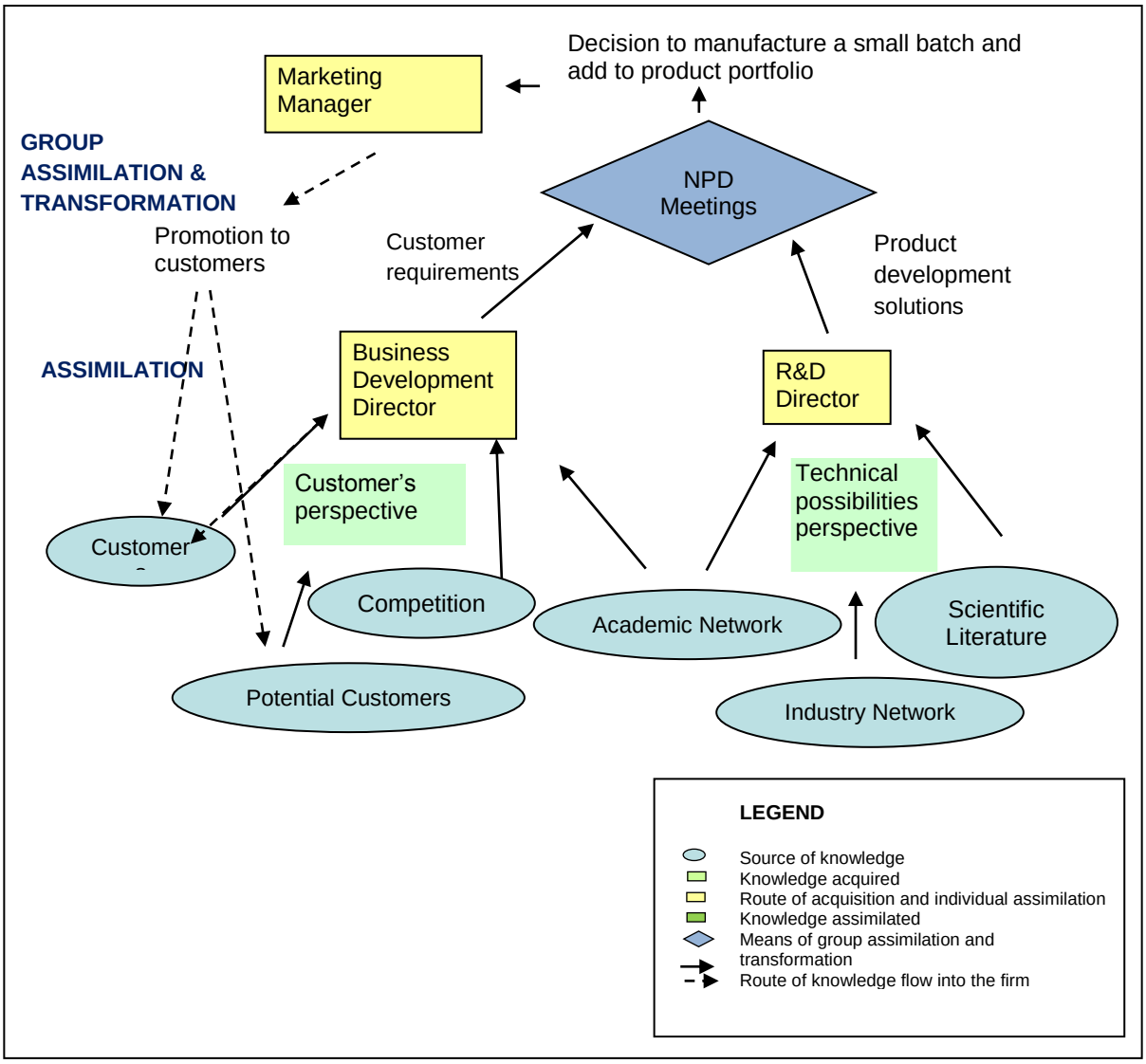
Case A has a large product portfolio, which is constantly changing as the firm develops new products. Figure 6.6 demonstrates this firm's routine process for the acquisition and assimilation of external knowledge, which is exploited through the development of new products that provide the growth outcome for the firm. The development of new products is driven by external market knowledge from customers, potential customers and competitors, combined with external technical knowledge from scientific literature and academic networks. These two perspectives are assimilated into the firm via the Business Development Director and the R&D Director, who interpret what this knowledge might mean for the firm. The R&D capability in Firm A is high and therefore, the team of chemists, led by the R&D Director, is adept at the development of new molecules that can solve customer problems. This combination of external knowledge and internal capability is transformed at New Product Development meetings which are held every 6 weeks, where decisions are made about whether the add a potential new product to the product portfolio.

It is a challenge for a small company to devote resources to building relationships with all the key influencers when they do not generate the volume sales, although they have the potential to be very influential in specifying future manufacturing processes. The Business Development Director describes how the firm utilises its significant experiential knowledge in the industry enables the firm to understand the dynamics of the industry and build relationships with key players that specify the production processes:

> *"Biotech drug discovery and big pharma. Now, it is hard to tell them apart because all of the big Pharma are acquiring some drug development companies. So, that led us to talk to them and actually, now our strategy is to talk to these guys to help drive the six big manufacturers because these are the specifiers. We've really discovered in the last six months or so. Things only happen here when these guys say 'This is what we want' and it's logical when you think about it"* AR1 2009/1/5

> *"The dynamics of this is that these people* [GMP manufacturers] *are our customers, so we would sell to those but they are not really the determinants of what goes into the product. These companies* [Pharma] *are the determinants. The pharma companies who are ultimately going to sell the product. There's a further complication. Most of the products being developed are not actually being developed by Pharma. Pfizer, GSK and so on have a number of strategic alliances with small biotech. The idea is ultimately these are the people* [GMP manufacturers] *that we'll be selling to, but what we need to contact these people* [pharma and biotech] *and say to the: 'If you're thinking of going down that route, the reagent you want to try and use is this one because it'll solve your…It will prevent you having this problem later on, it'll add this attribute to your molecule. So it is going to be a useful thing for you to consider. So in your research programme try to think about using that.'"* AR1 2008/23

Figure 6.6: Acquisition and assimilation of knowledge for new product development



Source: Developed by the researcher from analysis of interview transcripts

> *"We had already had some contact with these guys* [GMP manufacturers], *so the thing was to sit down and talk to them about what they were planning. And now it's closing a loop so what we have got to do we tell them* [Pharma and Biotech] *what we have got will make their life a wee bit easier and then we talk to them. 'You really want to make your manufacturer's life easy. So, what you want to do is incorporate this into your molecule early on.' So there is a two-pronged attack"* AR1 2009/5

Figure 6.7 illustrates the firm's understanding of industry structure and the relationships that Case A has with different parts of the industry. This stock of knowledge comes from many years of operating in the industry and by being well connected to key players. Figure 6.7 highlights the relationship between pharmaceutical companies and the GMP manufacturers they outsource to. As the pharmaceutical company has developed the DNA therapeutic to the point where it outsources the manufacture to one of these specialist GMP

manufacturers, once it reaches the point of GMP manufacturers being involved, the production process is already specified and approved by regulators.

The assimilation of this knowledge about the market dynamics enabled Case A to understand who they needed to influence and also the significant time delay between working with a pharmaceutical or biotech company to include a Case A reagent in the early research phase manufacture and volume sales for the firm, as described below:

> *"The lag it depends on where people are on the development phase of their new drug. So from the point that someone designs the molecule to it getting into pre-clinical size, scale of sufficient scale to get to the manufacturer, you are probably talking about 18 months"* AR1 2009/1/6

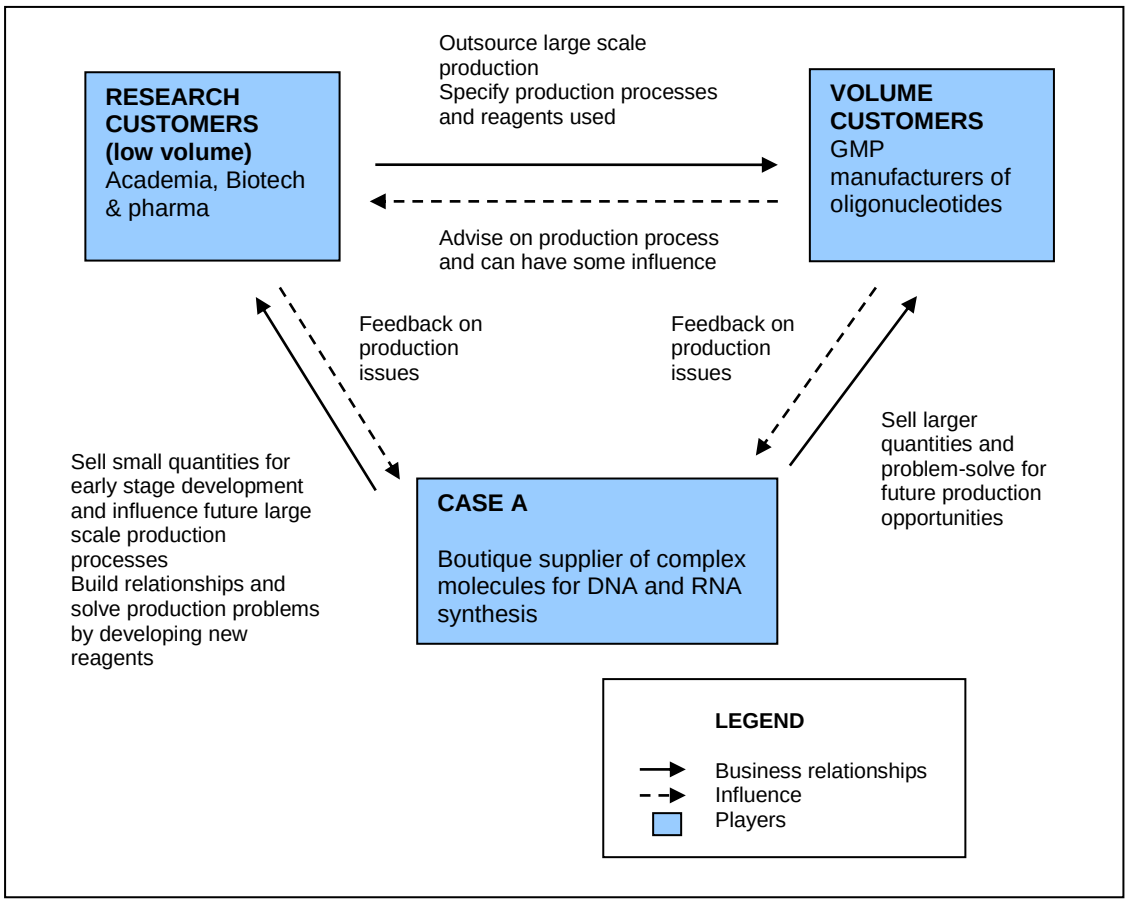
> *"Then as it goes into pre-clinical trial you need more so you actually start talking to larger scale manufacturers. It is at that point we want it specified because as soon it starts the clinical trials that's that molecule locked in. Not absolutely locked-in, but in terms of cost because to go back and start building all the data with another molecule is not something that so that's done. We are there at the moment. We've got to get in as early as possible to these guys to get this specified so in the example that we are talking about we are about a year in and it's still not with a manufacturer yet"* AR1 2009/1/6

The growth outcome of large-volume sales of a specific reagent to the GMP manufacturer is path-dependent on a number of issues such as the early stage drug/diagnostic getting to the stage of development where it will be entered into a clinical trial and that trial being approved by the regulators. However, the reagent must become part of the manufacturing process at the early stage of development.

With the objective of having their reagents used within the manufacturing development of DNA therapeutics, Firm A acquired external market knowledge gained from customers and potential customers about problems they encounter, and attempted to resolve these problems by manufacturing new products. Business Development staff and Marketing staff all have a chemistry background and can assimilate customer problems into appropriate challenges for the R&D department. The R&D Director also acquires knowledge directly by meeting industry contacts at conferences. The development of a cholesterol molecule from non-animal sources is an example that demonstrates new product development, with the aid of customer feedback, thus creating competitive advantage for the firm. The firm, based on previously assimilated market and technical knowledge perceived that a cholesterol molecule would be required in significant volumes. It was developed through the R&D department and added it to their product portfolio. The Marketing Manager and Business Development Director describe how having assimilating feedback from

customers and potential customers on the initial product developed, and understanding the impact of FDA regulation in terms of product safety, the firm developed a new cholesterol molecule from non-animal sources.

Figure 6.7: The firm's understanding of the industry structure and the relationships with different parts of the value chain



Source: Developed by the researcher from interview transcripts and diagrams drawn by Respondent 1 during an interview in 2008.

> *"The cholesterol CPG, for example, we would maybe make a product on a very small scale, more of an R&D scale, put it out there and see if anyone was interested. If you like, we would have a wee bit of market knowledge. And if it didn't cost us a lot, we would just do it. We already knew from speaking to people that it was going to be a product that was of interest to a lot of people, they couldn't get the kind of product that they wanted and we knew from the outset that they would want it on a reasonably large scale."* AR3 2009/2

> *"Yes, that was another piece of feedback we got from six manufacturers, they said 'Great, but we are going to hit a problem with the FDA.' What they are going to say is 'Where did this cholesterol come from? Does it come from sheep or cow's pancreases?' That's the two main sources of cholesterol and those obviously have problems with BSE & TSE the general TSE. So that was a bit of feedback that the six said. 'This was great, this is a nice molecule but can you guarantee that this is virus-free.' Now we thought, there is a way of doing that you can go and do sign tests and make sure that BSE doesn't get through the process. But we tackled it from another way is there any other way to get the materials that go into the molecule from a non-animal source. Mexican yams don't as far as I know get BSE. If mad*

> *Mexican yam disease ever develops, we are in real trouble. So it's a constant sort of feedback loop you solve one problem here and what happens if somebody tells you about another little thing that would help you…"* AR1 2009/7

By building relationships with all aspects of the industry, the firm has been able to become involved with the drug development process early, developing products that solve manufacturing problems, and selling small volumes of reagent to pharmaceutical and biotech companies during the manufacturing development process, which in turn influences the choice of reagents used in volume manufacturing, and has enabled the firm to enter the volume market successfully.

6.6.4 Knowledge processes to address the challenge of building and cementing of relationships with volume manufacturers

During the implementation of the scale-up and ISO, the Business Development Director understood that to become a supplier of choice, the firm faced the challenge of building relationships with GMP manufacturers, delving deeper into the drivers of this particular sub-sector of the industry.

> *"We were talking to them* [GMP manufacturers] *anyway, and then we were talking to them about 'How do we get more business from you guys?' and in some cases get some business from them because in some cases we were not doing any business with these guys. In fact, for most of them, we were not doing any business. For one or two of them, we were doing one or two wee bits of business, and it was just that basic question of "How can we do more for you?" and that is where the discussion started on the qualification."* AR1 2009/1/3

If reagents produced by Case A are specified into a drug manufacturing process long before the drug reaches that stage of development, the firm is not completely guaranteed as a supplier, even if their reagents were used by the pharma or biotech that developed the drug. The GMP manufacturer could buy from someone else.

> *"It doesn't give us a huge advantage because anybody worth their salt can take the molecule apart and do it. We know how to do it, we brought it to people, so they will tend to stick with us provided the cost is right. If costs start to go wrong they will look elsewhere so it's our job to provide them with the quality and price they are comfortable with but we don't have a protection in there that prevents these companies going elsewhere sadly"* AR1 2009/1/6

Understanding who drives the deal is key tacit market knowledge that the firm required to understand how to build a service around the product to win and maintain business. This information was not readily accessed or understood without building significant relationships with these players and having a full understanding of the industry.

At this time, the company had been looking for a company Chairman. The Business Development Director describes how Case A appointed an individual who had significant experience of GMP manufacturers, who provides additional gravitas to the firm in serving this new market.

> *"Yes, he's also able to open doors because of his position. He was chairman and CEO of one of the big six manufacturers. Because, if he became our Chairman, there was a kind of validation of what we were doing"* AR1 2009/1/14

The Business Development Director explained how the firm developed a profile of each of their key target customers.

> *"A good bit of reading of articles about these companies and trying to build up a picture of what the companies looked like and what are the characteristics, What kind of things did they do? What are their drivers? What are their problems? and so on… And we've got for each of these companies, these are all our key accounts. We've built over time a compete profile of these companies, their new feeds. Every announcement they make, we look at that, we figure out if there's any business in that for us. Who are they working with etc."* AR1 2008/23

> *"In our profiles of these companies for each of the individuals we have their hot buttons. Obviously the purchasing man wants it cheap, reliable, and so on. The production manager is looking about ease of use they are looking at the impurity profile of the material, so how do we control that so how do we make sure that every time he gets a batch of stuff its going to have exactly the same profile"* AR1 2009/1/8

> *"We spend a lot of time making sure that we do a very good job for them so we become their supplier of choice in the early stages"* AR1 2008/14

Figure 6.8 illustrates the knowledge processes that enabled Case A to cement their relationship with GMP manufacturers. This process was repeated across all key volume customers. As the relationship deepened, more Case A staff became involved in working with different departments within the GMP manufacturers.

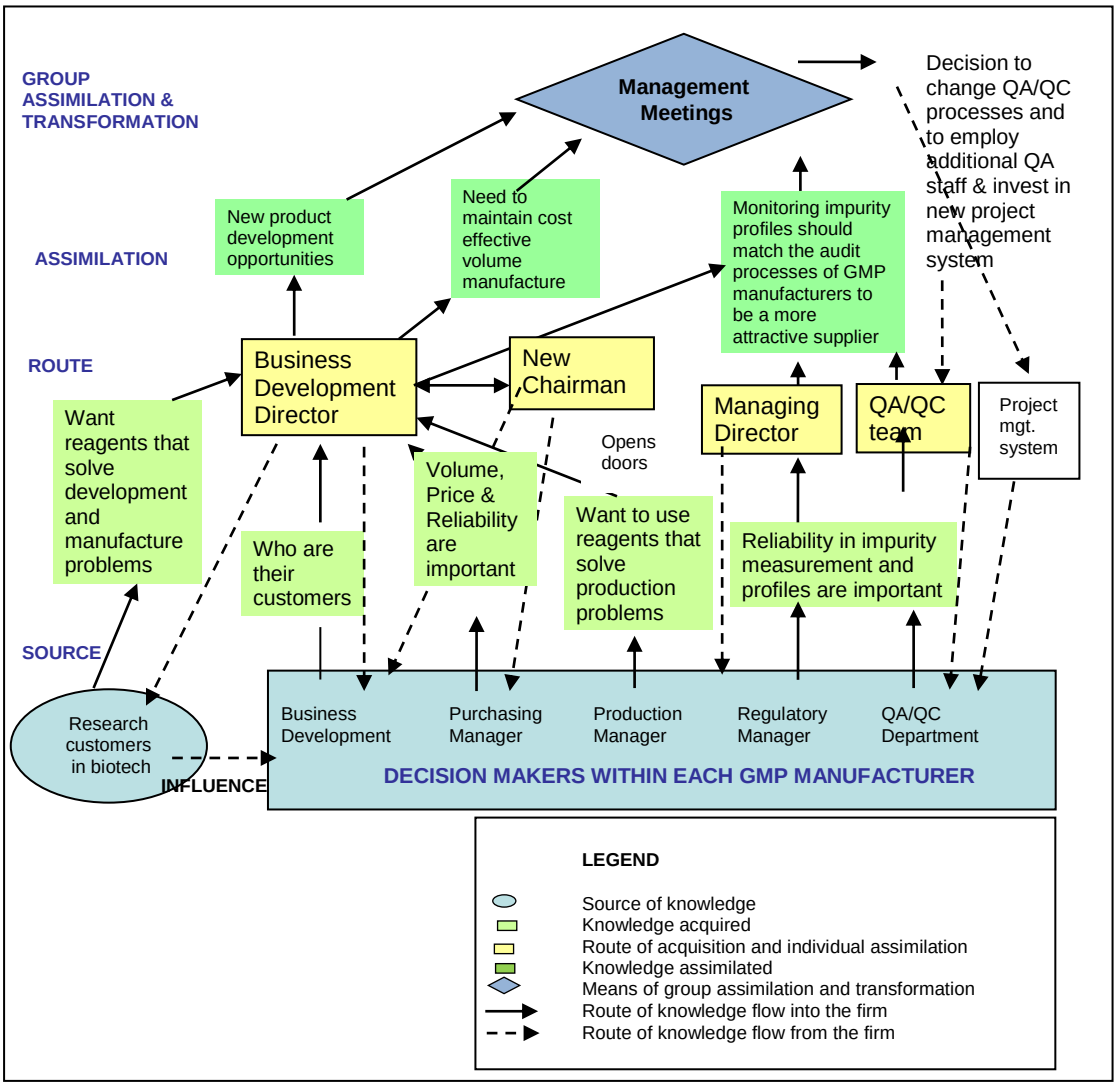
> *"…again it's a sort of iterative process. It got right down to understanding who in those six manufacturers drove the deal. So the logical thing was to start talking to the purchasing manager or do you start speaking to the production manager? Well as it turns out, you have to speak to both of them and you need to speak to two or three other people as well. Because then you need to speak to the regulatory manager whose dealing with the FDA. You also need to speak to their project managers the people who speak to the customers so you have to build up an entire picture of almost as to how that company operates"* AR1 2009/7

From 2008, Case A had two of the target GMP manufacturers as customers, and at that stage, with a more formal contract in place, there was a significant knowledge transfer between the firm and customers, in particular technical and regulatory knowledge.

> *"You don't get there* [having in depth discussions with GMP manufacturers] *until you've done all that. You're starting to spend a lot of time they're spending a lot of money so that you don't enter into it until… In fact, we had to sign. We didn't get into the discussions until we had signed the financial agreement to go ahead and then you can start spending the money. So for example next Friday two of our chemists are going to the States to spend a week. Then in two weeks' time two of*

their chemists will come here so there is a fair amount of now exchange got to on between the two companies" AR1 2009/8

Figure 6.8: Acquisition and assimilation of knowledge to cement relationships with GMP manufacturers



Source: Created by researcher from analysis of interview transcripts

On top of the ISO quality standard, these customers also require an impurity profile for the reagents being purchased to be used in GMP manufacture, and require that impurity profile to remain the same (within agreed tolerances). This has led to further investment by the firm in the form of additional human capital for quality assurance.

"And there are still going to be ramifications, particularly on the quality side of things, so OK we have ISO, but when we really start to getting into the impurity profile and doing a lot with pharma, and with diagnostics, we are going to need extra quality assurance person." AR4 2009/8

The transformation and exploitation of knowledge from these potential customers has had an impact on the way in which case A operates its production and quality assurance

processes, and in particular the measurement on impurity profiles of the relevant products, to tie in with the QA processes of the GMP manufacturers.

> *"Controlling the impurity profile turns out to be really really important. So that means working with the QC people to see how they measure ... We talk to their QC people on each occasion and ask well how are you measuring the impurities because we'll need to measure them in the same way. We are just about to embark on a very major contract with one of the big six to do an entirely new monomer and we are doing it in conjunction with them. They did a lot of the initial chemistry and we are scaling it up and that's exactly what we are now talking about here is our analytical methods we need to get simpler analytical methods that are more production orientated. So it's all down to this profile we've got to be able to produce and measure the profile produce to that profile and measure to that profile"* AR1 2009/8

Case A has also developed a project management system that links with their new customer relationship management system to allow customers to access their project on firm systems at an appropriate time. Due to the onerous monitoring of suppliers required by the FDA, if the GMP manufacturer already has a reliable supplier of that reagent it is unlikely to use another supplier. This is again a proactive step to cement relationships with customers by sharing knowledge.

6.7 A summary of knowledge leveraged during the critical event

In this case, the knowledge antecedent of the critical event is the recognition of a potential market opportunity by key members of the management team (See table 6.2). The market knowledge that is acquired is in the main tacit and not readily available. These individuals gain access to this knowledge through their relationships with key players in the industry. The outcome of the leverage of this knowledge is the understanding that there is a potential new market opportunity, but further knowledge is required to evaluate the requirements of the market against the fit with the capabilities of the firm.

Table 6.2 A summary of knowledge leveraged as the antecedent to the critical event

Knowledge leveraged (t/e)	External source (t/e)	Role	Outcome
Market knowledge (t &e)	Trade press (e)	BDD	Recognition of a potential market opportunity which requires further knowledge to fully evaluate
	Conferences (t & e)	BDD & RDD	
	Potential customers (t)	BDD & RDD	
	Research customers in pharma and biotech (t)	BDD & RDD	
	Market research (t & e)	BDD & RDD	
Technical knowledge (t&e)	Academic network (t & e)	BDD	
		BDD & RDD	
	Scientific Literature (e)		
t/e = tacit or explicit knowledge BDD = Business Development Director, RDD = Research and Development Director			

Source: Developed by the researcher from analysis of the case

This case demonstrates the critical role of individual members of the management team, as they bring knowledge from different perspectives to resolve the four challenges that the firm faced in this critical event. A summary of the knowledge leveraged by the firm for each challenge is outlined in Table 6.3. The ability of these key individuals to recognise the value of knowledge is dependent on their prior experience. Furthermore, their access to tacit market knowledge is dependent on the networks of relationships and connections that these individuals have built over time. The firm's new Chairman, who is well-respected and connected in this niche market, was instrumental in opening doors in this market. The firm began to build relationships with the 6 key potential customers in this new global niche market, and as the relationship grew, the firm was able to uncover more knowledge that allows it to alter its service offering to address the needs of these key customers more effectively.

For every growth challenge associated with this event, the firm can be seen to leverage different types of knowledge, which are combined to find solutions and build the capabilities that enable the firm to enter this market.

Table 6.3 A summary of knowledge leveraged for resolution of growth challenges associated with the critical event

Challenge	Knowledge leveraged (t/e)	External source	Internal source	Role
Producing larger volumes of product	Market knowledge (t &e)	Local network (e) Competitors (t & e) Existing customers (t) Potential new customers (t)		MD MD & BDD
	Management knowledge (t &e)		Profitability monitoring (t&e)	MD, PM, MM,BDD RDD
	Technical knowledge (e)	Scientific literature (e)	Experience of larger plant (t)	RDD MD, PM
Achieving required quality standard	Regulatory Knowledge (t &e)	QA consultant (t) UKAS Quality (e)	Experience of ISO standard and internal QA system (t)	MD
	Market knowledge (t &e)	Existing customers (t) Potential new customers (t& e)		BDD
New product development	Market knowledge(t &e),	Existing customers (t) Potential new customers (t& e) Competitors (e) Industry network (t&e)		BDD
	Technical knowledge(t &e)	Existing customers (t) Potential new customers (t& e) Scientific Literature (e) Academic networks (t&e)	R&D experience (t)	BDD RDD BDD, RDD
	Regulatory knowledge (t &e)	Existing customers (t) Potential new customers (t)		BDD
Building and cementing relationships in multiple geographies	Market knowledge, (t &e)	Potential new customers (t)		BDD, Chr
	Internationalisation knowledge (t &e)	Potential new customers (t)		BDD
	Technical knowledge (t)	Potential new customers (t)		BDD, RDD
	Regulatory knowledge	Potential new customers (t) Research customers (t)		MD, QA team

t/e = tacit or explicit knowledge
BDD = Business Development Director, RDD = Research and Development Director, MD = Managing Director, MM= Marketing Manager, PM = Production Manager, QA = Quality Assurance, Chr= Chairman

Source: Developed by the researcher from analysis of the case

6.8 Growth outcomes from the leverage of knowledge

This case has outlined a number of intertwined knowledge processes of firm A over a four year period, which has enabled the scale-up of manufacturing facilities and ISO accreditation, which enabled the firm to enter a new market.

> *"There's been some immediate effect on who we're speaking to and the kind of business that we have the potential to do. At the moment the volume and the financial rewards from doing that are still being built up. We have a good and regular customer in Korea who is a GMP manufacturer and one in Germany has now become a customer."* R1 2008/17

A year later, the Business Development Director describes the significant time lag in this industry and expresses the time taken to start supplying volume customers.

> *"That's us beginning to get there, that's the fruits of all that work. I've now put a tick in the box- that we have been successful for that one company. But it's a long process a long, long process."* R1 2009/9

This has now begun and Case A expects to see significant growth outcomes in terms of volume sales and profitability in the future. Together, this has allowed the firm to move to the next stage of growth and profitability.

6.9 Enablers to the leverage of knowledge

This case highlights five key enablers to the leverage of knowledge for this firm:

Experiential knowledge

This case study highlights that the experiential knowledge of individuals within the firm is a key enabler of the absorptive process, impacting on all dimensions, from enhancing individuals' ability to assess the value of particular knowledge, combining it with internal knowledge and interpreting what it means for the firm, to the realisation of new opportunities which can be exploited. Furthermore, experiential knowledge is key to the speed of exploitation of knowledge.

Social Capital

This study finds significant evidence that the social capital of the firm plays a key role in facilitating the search for knowledge. In particular, the relationships that are built enable the access to the tacit knowledge the firm requires. This case also highlights the benefits to the firm of the social capital of board members. The new Chairman can be seen to be opening doors for the firm in a market where he is well known and respected. The

relationships that individual members of the management team have developed enables the firm to access timely knowledge it requires.

Organisational culture

This firm proactively scans the environment, and this culture of open innovation is shown to be a key enabler for sourcing the combinations of knowledge they require in order to resolve the challenges associated with critical event for the firm. It has acquired knowledge from multiple sources of knowledge from published explicit knowledge, but much of the knowledge they require is tacit and can only be accessed through building relationships. Organisational culture is also seen to have a role in empowering staff to find solutions to challenges being faced by the firm.

Governance

The governance of Case A meant that when the combination of new external knowledge and existing knowledge stocks within the firm created a 'tipping point', the Directors were able to make quick decisions to invest their own cash reserves with the expectation of the next phase of growth for the firm. Although there was no requirement to put a case to external investors, there was a significant investment in the scale-up of production facilities and the Directors had to be convinced of the growth potential.

> *"I had to be convinced that there was the potential market there. I could see from the production side of things, from the existing sales that certain products were selling better and better, bigger volumes and we learned from that. I think rather than just myself, we all had to be convinced that there really was a xxx*[product] *that pharma will buy"* AR4 2009/7

> *"I think for a small company with limited resources, you are making decisions based on inadequate information. You never have enough information. You are always wanting to do a bit more research before you commit yourself. So in actual fact the moment you say 'Let's just go ahead' is when you feel reasonably comfortable that what you know suggests you are on to something important"* AR1 2009/1/11

> *"... this is our hard earned cash we could spend it on a number of different things including giving it to ourselves yes it's a gut wrenching decision you've just got to summon up your courage and go for it."* AR1 2009/1/13

Effective communication across the firm

This case illustrates the importance of the individual in recognising the value of knowledge and acquiring it for the firm. It also shows that different types of knowledge, sourced by different individuals, need to be combined in order for solutions to be found to challenges.

A key part of harnessing individual ACAP for the benefit of the firm is effective dissemination of knowledge throughout the firm.

Power relationships within the industry

This case illustrates that a successful growth outcome in terms of commercial sales volume is dependent on a number of factors out-with the control of the firm. This case demonstrates the impact of the strict regulation of the industry by regulators such as the FDA and MHRA have on all activity. The firm can only generate sales revenue from these relationships if the DNA-based drug in question successfully enters clinical trials. This is a risk that the firm has to assess as part of the opportunity evaluation.

6.10 Conclusions and implications

The findings from the within-case analysis of Case A are as follows:

- The critical event for this firm, which was the decision to enter a new global niche market, involved activities linked to all three key drivers of small firm growth: entrepreneurship, internationalisation and innovation.
- The challenges that faced the firm in relation to this critical event were four-fold, and were tackled simultaneously by the firm:
    - Being able to produce the volumes required to service this market.
    - Bringing production processes to the required quality standard to achieve ISO accreditation.
    - New product development for this market, influencing the decision makers earlier in the value chain that specify the inputs to the process.
    - Building and cementing relationships with potential customers in this market, who are located in multiple geographies.

- This case demonstrates that the iterative nature of knowledge processes that enabled the firm to resolve the challenges associated with this critical event.

- The knowledge antecedent of this critical event was the recognition that a change in the market might lead to a new market opportunity, which proved to be a 'tipping point' for the firm. This case therefore also demonstrates the cumulative effect of

knowledge, as both the external market knowledge about cost pressures in the industry and internal knowledge about production volumes and efficiency had been building for a number of years, but the decision to scale-up was not seriously considered until 2005, when this new market opportunity arose.

- The firm combined different types of knowledge from different sources to resolve the challenges it faced. This case highlights the importance of individuals in recognising the value of knowledge in the external environment and sharing it with colleagues.

- The key enablers of the leverage of knowledge in this case are: experiential knowledge, proactive knowledge search, social capital, governance and effective internal communication. This case demonstrates the impact of prior knowledge and experience of the firm directors and firm governance on the speed to exploitation and firm growth.

- This case illustrates the relationships and networks required to elicit the tacit knowledge required to understand the market dynamics and the needs of customers. Access to tacit market knowledge is particularly dependent on the relationships of key individuals within the firm and key customers.

- This case demonstrates the importance of building relationships across the value chain in order fully to understand the industry dynamics and to be able to influence key decision makers.

These findings are taken forward to cross-case analysis in the following chapter.

Chapter 7

An absorptive capacity based cross-case analysis

7.1 Introduction

This chapter presents the findings of cross-case analysis described in the methodology chapter. Within-case analysis has been conducted for all cases, as for the example case presented in Chapter 6. However, individual case narratives, visual maps and matrix analysis for all cases are not published in this thesis due to the commercially sensitive nature of the data. The examples used in this chapter have been anonymised.

Firstly, this chapter presents findings from the analysis of the critical events identified for each individual case and outlines the growth challenges that HTNVs faced at these events. This research highlights that although firms can view critical events in a slightly different way, the key drivers of growth are all evident as the firms resolve the multiple challenges associated with each event.

In keeping with the ACAP lens that has been used in this study to explore how firms leverage external knowledge to find solutions to their growth challenges at identified critical events, the cross-case analysis focuses on the dimensions of ACAP process: *acquisition, assimilation, transformation and exploitation.*

As this thesis is concerned with understanding how HTNVs leverage knowledge, the cross-case analysis initially explores the knowledge antecedents that precipitated these events, examining how that knowledge was acquired. In order to understand how firms leverage that knowledge. It goes on to describes the types of knowledge that cases have required in order to address growth challenges associated with the events that the antecedents precipitate.

This chapter progresses through the dimensions of the ACAP process from acquisition of external knowledge, to assimilation and then to the transformation and exploitation of that knowledge into capabilities that generate growth. In doing so, the study identifies key enablers of the leverage of knowledge. Lastly, the analysis focuses on social capital as

a key enabler of the leverage of knowledge and examines which relationships are effective in facilitating the resolution of the growth challenges identified by the firms. In doing so, this study sheds new light on the leverage of knowledge by HTNVs.

7.2 Critical events for HTNVs and their associated growth challenges

The nature of the critical events identified by this study

The seven firms in this study have all transitioned through a series of critical events which has enabled them to move to a further period of growth. The nature of the critical events identified by the case firms varies in each case and is specific to the context for that firm. For example, for the five very young HTNVs in the sample, the foundation of the firm is perceived as an event for the firm; for five firms, critical events involved entering new markets and developing products or services for that market; for two of these firms that could be classified as technology-push firms, the critical event involved taking products developed by the firm to market; for two firms, a change in strategic direction was a key event; while for another two cases, the development of a collaboration agreement to enable the firm and their partner to develop joint services was a critical event which enabled the firm's development and growth. Table 7.1 summarises the critical events identified by the firms in this study. These events were triggered by a knowledge antecedent which is explored further in section 7.3.

Growth challenges associated with critical events

Although case firms identify different events as being critical to the growth and development of the firm and these are unique to the context of each case, when these events are examined in more detail, these events are found to involve a number of challenges the firm has to surmount. Cross-case analysis highlights that a number of cases face common challenges. For example, for the two firms that identified a change in strategic direction to focus on a single aspect of their business model as a critical event, the associated challenges faced by these firms are similar to the other firms developing new products and services for a new market. Table 7.1 summarises the critical events identified by the firms in this study, and outlines the associated growth challenges found during the within-case analysis.

Table 7.1 Critical events, their knowledge antecedents and growth challenges by case

Case	Knowledge antecedent	Critical events	The challenges associated with these event (Drivers of firm growth E/Inov/Int)
A	Becoming aware of a potential high volume market opportunity	Decision to enter a new strategic market	• Being able to produce the volumes required to service this market. (Innov) • Bringing production processes to the required quality standard to achieve ISO accreditation. (Innov) • New product development for this market, influencing the decision makers earlier in the value chain that specify the inputs to the process. (Innov & E) • Building and cementing relationships with potential customers in this market, which are located in multiple geographies. (Innov, E & Int)
B	Becoming aware of service business opportunity	Entering a new market to aid cash flow	• Building relationships with potential customers • Developing a service portfolio (Innov) • Achieving Good Laboratory Practice accreditation (Innov) • Assays needs to be validated (Innov)
	Change in pharma buying behaviour leads to a threat to instrument business	Change in strategic direction to focus on service business	• Building portfolio of validated assays (Innov) • Building relationships with customers (E & Int) • Sourcing reliable supply of high value consumables (Innov, Ent & Int) • Fundraising (E)
D	Founders becoming aware of a gap in the market	Foundation of the firm	• Developing a portfolio of services and complying with regulatory requirements (Innov) • Building relationships with customers • Sourcing reliable supply of high value consumables (Innov, Ent & Int)
	Customer requests lead to an understanding that there is a new service opportunity	Collaboration agreement with outsourcing partner enabling the provision of a new service	• Develop internal capability vs outsource decision constrained by lack of resources (E) • Sourcing & evaluating collaboration partners (Innov & E) • Building relationship with potential partner (E & Innov)
E	Becoming aware of a gap in the market	The foundation of the firm	• Fundraising (E) • Developing a service portfolio and complying with regulatory requirements (Innov) • Building relationship with customers (E, Innov & Int)
	Stricter regulatory control increases customer requirements, and customers do not want to split samples	Collaboration agreement to jointly provide a holistic service	• Develop internal capability vs outsource/partner decision (E) • Source partner with complimentary capability (Innov & E)
F	Becoming aware of technology which led the founders of the firm to believe there could be a successful medical device.	Foundation of the firm In order to take this product to market. Getting the first product to market	• Fundraising from VCs (E) • Developing the product (Innov) • Sourcing a suitable manufacturing partner for the product (Innov & E) • International market entry strategies including attaining regulatory approval in multiple geographies (Int & Innov)
G	Understanding a market opportunity for technology developed by academic	Foundation of the firm	• Fundraising (E) • Developing the lead product (Innov) • Gaining service clients (E & Innov & Int)
	Service business is a distraction to product development	Change of strategic direction from dual business model to focus on product development and getting the first product to market	• Selecting a route to market (Innov) • Building relationships with potential marketing partners(E & Int) • Developing the product to required specifications (Innov) • Sourcing manufacturing partner (Innov)
I	Understanding unmet clinical need as a market opportunity	Foundation of the firm Getting the first product to market	• Fundraising (E) • Choosing lead product (E & Innov) • Selecting development partners (E & Innov) • International market selection & achieving regulatory approval in 1st market (Int & Innov) • Entry mode selection in 1st market (E, Int & Innov)
Drivers of small firm growth: Innov= Innovation, Int = Internationalisation, E = Entrepreneurship			

Source: Developed from within-case analysis of critical events

predominantly overseas. The HTNVs in this study demonstrate a high level of innovation. Seven of the growth challenges identified in this study can be categorised as an element of Schumpeter's (1934) 5 types of innovation, outlined in section 2.8. In addition, as all these firms operate in global niche markets, their market development inherently involves internationalisation. Furthermore, firms demonstrate their entrepreneurship in balancing their resources to support the requirements of these activities. The key integrated entrepreneurial processes involved in each growth challenge are identified in table 7.1.

It is evident from this study that firms in rapid growth (case E) or making major changes within the firm in order to position themselves for rapid growth (cases A & B) have multiple challenges to overcome. These firms are tackling a number of challenges simultaneously, partly because the three key drivers of growth are all interconnected, but also because of the limited time window available to capitalise on these opportunities necessitates tackling multiple challenges simultaneously in order to maximise the speed that the firm responds to the opportunity. This is particularly evident in this study where due to the dynamic nature of the life science industry, windows of opportunity can be short. This evidence supports the holistic approach to key integrated entrepreneurial processes taken by this study. The key growth challenges identified by cross-case analysis are outlined below and summarised in table 7.2 and are mapped to Schumpeter's (1934) 5 types of innovation:

1. *New product and service development (product innovation)*

   The cases in this study are all HTNVs founded to capitalise on technological innovation. Therefore, not surprisingly, the cross-case analysis highlights new product and service development as being a key challenge for all firms. The constant scientific advances in this industry provide new opportunities for HTNVs, but also require the firms to keep abreast of new technological innovations and ensure that any scientific advances are factored into new product development. It is also evident that this challenge is closely linked with market development and internationalisation.

2. *New market development (market innovation)*

   As the firms in this study are all HTNVs, the markets they are entering are often so new that they are effectively creating the market as they develop the technology (cases B & G), where the benefits of the innovation have to be clearly demonstrated in order for widespread adoption of the technology by the market. In case A, the drive for technological development within the firm has come from the demands of the new market they have chosen to enter. It is also evident that for the specialist service providers in the sample (cases B, D, E), new market development opportunities are closely linked to the regulation in the industry.

3. *Internationalisation (market innovation)*

   The majority of the cases in this study (cases A, B, C, E & I) are part of a complex global value chain in which therapeutic drugs and vaccines are discovered, developed, go through clinical trials and are eventually licensed for human use. Although the homogeneous nature of products and services mean that little or no adaptation is required for different geographical markets, regulatory approval must be achieved in each market. As part of global value chains, HTNVs are highly dependent on the fortunes of bigger global players higher up the value chain and therefore need constantly to re-evaluate the dynamics of the industry environment and its impact on them. For example, case B made a complete shift in strategic direction as a result of changing behaviour by pharmaceutical companies. In contrast, cases F and G which are developing diagnostic products also have the challenge of choosing appropriate routes to market in the chosen international markets.

4. *Sourcing collaboration partners (new organisational forms)*

   This study highlights that resource constrained HTNVs do not always have the capacity or capability to respond to market opportunities on their own. Cases D & E highlight the challenge of evaluating the capabilities of potential collaboration partners in order to capitalise on a market opportunity together where the individual firms did not have the resources within the firm.

5. *Investment in new production or operational facilities (process innovation)*

   This study found that in four cases (A, B, D & F), respondents discussed investment in new equipment or facilities in order to be able to capitalise on a market opportunity. This represented major investment both financially and in management time and therefore this challenge can be closely linked to the raising of finance.

6. *Sourcing suppliers and outsourcing partners (Identifying new sources of supply)*

   For a number of firms in this study, outsourcing is central to their business model. For firms that operate a virtual model (cases D, F & I), a number of activities crucial to their success are outsourced and finding appropriate partners is a key task in fulfilling their growth ambitions. Supplier agreements are also key to the success of cases B and D.

7. *Achieving regulatory compliance (product & process innovation)*

   The life science industry is heavily regulated and the impact of regulatory bodies, such as the FDA (US)[5] and the MHRA[5] (UK), is very evident in the findings. Understanding the market dynamics in different geographies and how they are impacted on by the regulatory authorities is a key skill in life science firms. Attaining the relevant accreditation, regulatory approval or quality standard is highlighted by a number of firms (cases A, B, E, F & I) as a key challenge associated with product and service development in the life science industry. In three of the cases (B, D & E), the market opportunities upon which the firms were founded are directly as a result of safety regulation that demands therapeutic drugs for the treatment of humans be safety tested at all stages of their development and production. However, all three firms have had to set up their operations according to the Good Laboratory Practice (GLP) standard which is required by regulatory authorities in order to be able to work with drugs biologics and vaccines that will be used for human consumption. Life science firms with products, such as case F also have to have their products approved in order to sell to consumers, and this can impact on the realisation of growth ambitions.

   "we have regulatory hurdles to overcome in some markets, some of them we're there already. We've got MHRA approval which means we can sell in European countries. We've got approval in Canada. We've applied to the States and we're still waiting for that one… if we'd had FDA approval, we would have been a lot further on in the US market." FR12008/2

[5] *Regulatory authorities outlined in Glossary of Terms in Appendix 3*

Similarly, case A, which supplies components that go into a process which is regulated by the FDA/MHRA, has implemented the ISO quality standard in order to remove this barrier to entering a new market.

8. Raising Finance

Raising investment finance is evident as a significant growth challenge for most cases in this study. This study highlights that significant amounts of management time were taken up in securing investment, and that this took longer than they had anticipated, as articulated by these respondents:

> *"the disproportionate amount of time that you spend in Scotland in raising money is just crazy ."* BR52009/23
>
> *"We thought "How hard can it be?"… resign and go do it… and it took a year to get the first round of funding in. We got through the faltering first steps and we've created something that certainly it is valuable, and hopefully it can make a difference for people"* IR12010/6

Cases also expressed that in the recent financial climate, it is more difficult for firms to raise the amounts of investment they require. Although two cases (A & D) have been self-financed from their foundation and do not have external shareholders, they have still experienced the challenges of resourcing their growth ambitions.

Table 7.2 A summary of cross-case analysis of growth challenges faced by sample firms

Venture		**A**	**B**	**D**	**E**	**F**	**G**	**I**
Industry subsector		PS	PS	PS	PS	MT	MT	DD
Kanzanjian stage		4	2/3	1	2	2	1	2
Employment FTEs (at first interview)		20	12	2	23	7	4	3
Pace of internationalisation		INV	INV	INV	INV	INV	INV	INV
Growth challenges associated with identified critical events (Schumpeter's categories of innovation)	New product /service development (Product innovation)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	New market sector development (Market innovation)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	New international market development (Internationalisation & market innovation)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Sourcing collaboration partners (Organisation form innovation)		-	Yes	Yes			
	Investment in new production facilities /increasing capacity (Process innovation)	Yes	Yes	Yes	Yes	-	-	-
	Attaining quality standard/ regulatory authority accreditation or approval/adhering to regulatory guidelines (Process and product innovation)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Raising finance (Entrepreneurship)	-	Yes	-	Yes	Yes	Yes	Yes
	Sourcing supplier/outsourcing partners (Innovation)	-	Yes	Yes	-	Yes	Yes	Yes
Life science subsector: DD: Drug discovery and development, PS: Pharmaceutical services, MT: Medical Technologies Pace of Internationalisation INV: International new venture, INC/PTI: Incremental/Process Theory of Internationalisation								

Source: Cross-case analysis. Note: When discussing the critical events for the firm, respondents raised these issues as challenges they had to resolve

7.3 Critical events for HTNVs and their associated knowledge antecedents

Analysing across the cases in this study, it is evident that events that have been identified as critical by the firm have been precipitated by a knowledge antecedent which has acted as a 'tipping point' (Gladwell, 2000) for the firm. The knowledge antecedents for the critical events identified by the case firms are summarised in table 7.3. From further analysis of the knowledge antecedents, a number of themes emerge:

Firstly, knowledge antecedents that precipitate a critical event tend to come from a variety of sources, the majority of which are external to the firm. This study shows that a consistent message coming from a variety of sources increases the intensity of the message but also enhances the validity of that knowledge, which has a greater influence on the firm, encouraging it to evaluate this knowledge fully. Furthermore, this study demonstrates that before the firm acts upon a perceived opportunity/threat, it uses knowledge gained from other sources to validate and add to the initial knowledge it has acquired. (See Chapter 6, Figure 6.3 for an example from case A). This finding supports Zahra and George's (2002b:194) view that the intensity of the trigger influences the level of investment that a firm invests in developing the acquisition and assimilation capabilities required to evaluate an opportunity.

Secondly, this study highlights the cumulative effect of building stocks of acquired knowledge to a point where the firm is convinced that there is a real opportunity or threat. In cases A and G, technological knowledge was acquired over many years, highlighting the commercial potential for particular innovations, but the market for these innovations did not exist at that time. However, regular scanning of the industry environment for market knowledge highlighted a change in the market conditions, which when assimilated, was the 'tipping point' that led the firms to believe that this technology could now be successfully exploited.

Table 7.3 Critical events, their knowledge antecedents and how that knowledge was acquired

Case	Critical events	Knowledge antecedent	Know'ge type	Roles that acquired	Knowledge source (type of knowledge provided T/E)
A	Decision to enter a new strategic market	Becoming aware of a potential high volume market opportunity	MK, TK	Bus Dev Dir R&D Dir	Special interest groups (T&E) Customers (T) Potential customers (T&E) Trade Press (E) Scientific Literature (E)
B	Building the service business to aid cash flow	Becoming aware of service business opportunity	MK	CEO & COO	Potential customers (T&E) Market research (T&E)
	Change in strategic direction to focus on service business	Change in pharma buying behaviour leads to a threat to instrument business and an opportunity to service business	MK, TK	Sales Dir COO	Special interest groups within industry (T&E) Instrument prototype testing feedback (T) Links with industry (T)
D	Foundation of the firm	Founders becoming aware of a gap in the market	MK, TK	Dir 1 & Dir 2	Existing links with potential customers (T& E) Existing links with potential suppliers (T) Special interest groups (T& E) Existing links with a potential collaborator (T)
	Collaboration agreement with outsourcing partner enabling the provision of a new service	Customer requests lead to an understanding that there is a new service opportunity	MK	Dir 1 & Dir 2	Customers (T) Potential customers (T) Special interest groups (T& E) Competitors (E)
E	The foundation of the firm	M & A activity creates a gap in the market	MK	Sales Dir (2), CEO, Opps Dir	Existing links with potential customers (T& E) Special interest groups (T& E) Competitors (E)
	Collaboration agreement to jointly provide a holistic service	Stricter regulatory control increases customer requirements. Customers do not want to split samples	MK, RegK	Sales Dir (2), CEO, Opps Dir	Customers and potential customers (T) Existing links with academic networks (T&E)
F	Foundation of the firm In order to take this product to market. Getting the first product to market.	Becoming aware of technology which led the founders of the firm to believe it could be a successful medical device.	MK, TK	Dir 1, 2 & 3	Existing business connections (T & E) Market research (E)
G	Foundation of the firm	Understanding a market opportunity for technology developed by academic	MK, TK	CSO	End users (T & E) Potential customers(T) Special interest group (T & E)
	Change of strategic direction from dual business model to focus on product development and getting the first product to market	Market opportunity opening up for diagnostic assays Service business is a distraction to product development	MK, TK, MngK	CSO, Chair	End users (T & E) Potential customers (T) Special interest group (T & E) Internal evaluation (T)
I	Foundation of the firm Getting the first product to market	Understanding unmet clinical need as a market opportunity	MK, TK	CEO & Bus Dev Dir	Existing relationships within industry (T & E)

Types of knowledge: MK= Market knowledge, TK= Technical knowledge, Mng K = Managerial Knowledge, RegK=Regulatory knowledge, RelK= Relational knowledge, T = tacit, E = Explicit
Role: Bus Dev Dir= Business Development Director, R&D Dir= Research and Development Director, Dir = Director.CSO= Chief Scientific Officer, COO= Chief Operations Officer, Chair = Chairman, CEO =Chief Executive Officer

Source: Cross-case matrix of findings from within-case analysis

Thirdly, in this study, critical events identified by the case firms were mainly precipitated by market knowledge, which has come from customers and potential customers in the market place. This finding reinforces Zahra and George's (2002b) view that the source of the activation trigger influences the search for external knowledge. This study highlights in particular that the activation triggers from customers and other trusted knowledge sources are of particular importance. As the SMEs in this study operate in dynamic high technology niche markets, there is very little publicly available market information. Although some knowledge that has contributed to the critical events has come from explicit knowledge which is generally available to anyone operating in the industry, the majority has come from building relationships with key players in the given industry niche. This is achieved by being seen to be part of the special interest community through attending specialist academic or industry conferences for the appropriate special interest groups. Firms also develop relationships with customers and potential customers. Customers and potential customers also provide technical knowledge which enable firms to evaluate the technical requirements of the given opportunity. For very young firms, it is evident that the knowledge antecedents for foundation events were sourced via existing industry relationships built over many years from previous employment.

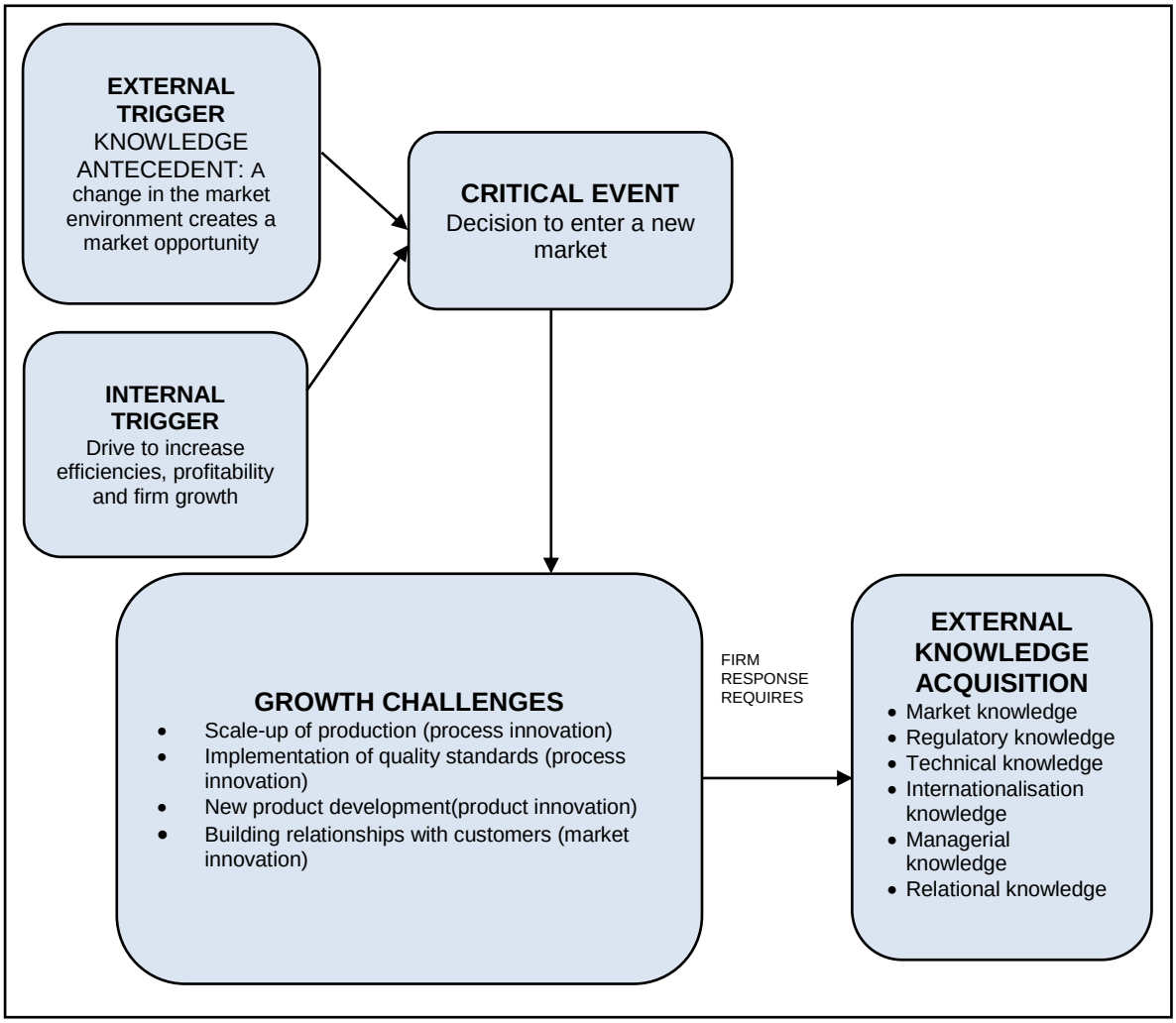
Fourthly, this study shows that opportunity recognition in HTNVs is dependent on the ACAP of a few key individuals recognising the value of knowledge (See table 7.3). This suggests that senior staff in HTNVs must be 'attuned' to combination of explicit and tacit knowledge and this individual ACAP is dependent on the prior experiential knowledge. Realizing these opportunities is dependent on these individuals disseminating the knowledge to colleagues. This study shows that a particular knowledge antecedent, when added to existing stocks of knowledge within the firm management team can act as the 'tipping point' to the firm. The dissemination of knowledge assimilated from different perspectives by different members of the management team brings a strong signal to the firm to evaluate this opportunity.

Lastly, findings from this research suggest that the firm may be more receptive to the knowledge antecedents due to internal drivers that encourage the firm to scan the environment looking for opportunities. This may also influence the firm's response to the triggers from the external environment. The wish to grow the firm is a fundamental

entrepreneurial driver and is the main trigger for proactive acquisition of external knowledge. It also suggests that individuals whose role it is to acquire knowledge should be aware of the firm's objectives and challenges in order that they can recognise the value of knowledge when they encounter it. This concurs with Shane's (2003) view that individuals are more likely to find information that is useful to the opportunity discovery process through a deliberate search.

An example of a knowledge antecedent precipitating a critical event for the firm is shown in Figure 7.1. This example has been explored in detail in Chapter 6.

Figure 7.1 Knowledge antecedents: Activation triggers to acquire external knowledge

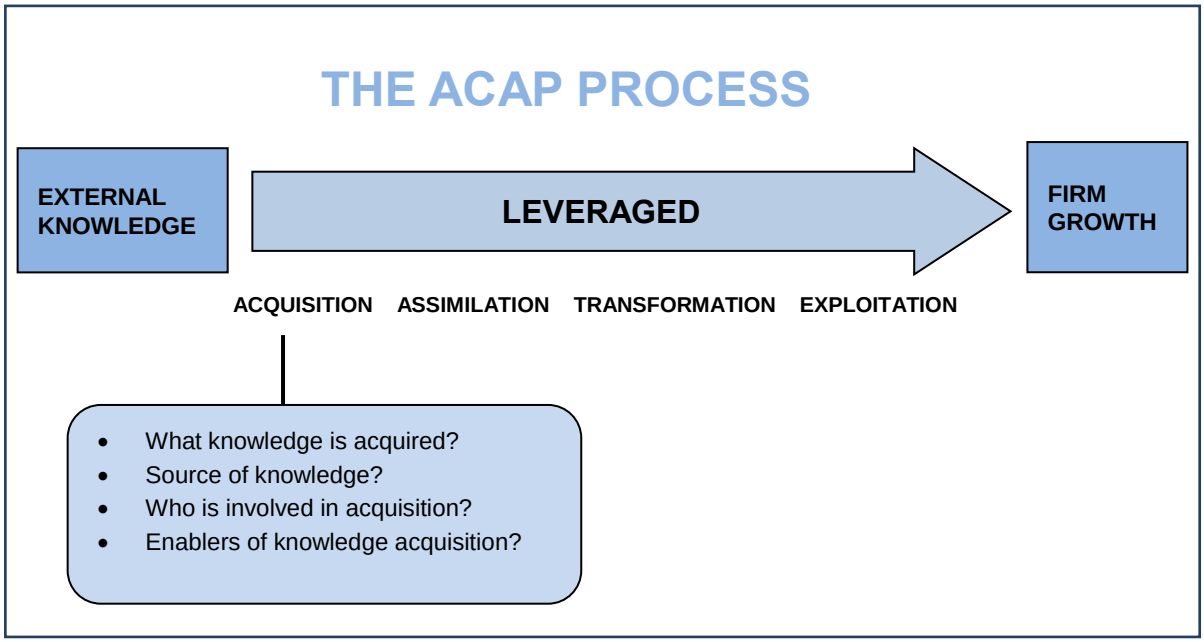


Source: Developed from within-case analysis of interview transcripts from Case A

7.4 Acquisition of external knowledge by HTNVs

This section presents the findings relating the first dimension of the ACAP process, the acquisition of knowledge from outwith the firm (see Figure 7.2). Firstly, this section examines the types of knowledge acquired and the sources of that knowledge. Secondly, the roles within the firm responsible for acquiring external knowledge are analysed, highlighting that HTNVs plug gaps in their ACAP by recruiting new human capital with the requisite knowledge and experience to be able to leverage new knowledge in given areas. Lastly, the enablers of knowledge acquisition are outlined with the importance of social capital being highlighted to access key sources of tacit market knowledge.

Figure 7.2 ACAP as a research lens – the acquisition dimension



Source: Developed by the researcher (adapted from Zahra & George 2002b:192)

7.4.1 Types of external knowledge required to resolve growth challenges associated with critical events

The firms in this study are all HTNVs whose demand for knowledge is acute but these firms are small and therefore do not have sufficient knowledge resources within the firm to

resolve their growth challenges. Therefore these firms must successfully leverage external knowledge to find solutions to their growth challenges. This section presents the findings regarding the types of knowledge that firms within this study have required to transition through growth challenges and these are summarised in Table 7.4. The cases revealed that particular types of knowledge appear critical for the resolution of complex interwoven challenges that HTNVs face.

Table 7.4 Growth challenges and the types of knowledge required to address them

Types of knowledge		**TK**	**MK**	**MngK**	**RegK**	**IK**	**Rel K**
Growth challenges faced at critical events	New product /service development (innovation)	A, B, D, E,F,G	A,B,D,E,G ,I	B	E		A,B,D,E,F, G,I
	Market development	A, B, D	A,B,D,E,F, G,I	A,B	A, B, E		A,B,D,E,F, G,I
	International market development	A,B,D,E,F, I	A,B, F,D,I		I, D	B,F,D,I	A,B,D,E,F, I
	Collaborations	D,E	D,E				D,E
	Investment in new production facilities /increasing capacity	A,E	A,B, E	A,B,E	A,E		A,E
	Attaining quality standard/ regulatory authority accreditation or approval	A,B,E, F,I	A, B,E		A,B,E, F,I		A,B,E, F,I
	Raising finance			B,E,F,G,I			
	Sourcing supplier/outsourcing partners	B,D,F,I	B, D				B,D,F,I
Cases A-I : Sample firms in this study Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=Managerial knowledge, RegK=regulatory knowledge, IK= Internationalisation knowledge, Rel= Relationship knowledge							

Source: Cross-case analysis of knowledge discussed when relating to growth challenges faced

7.4.2 Categories of external knowledge

This study has found evidence suggesting that six key types of external knowledge are required to provide solutions for the growth challenges faced by HTNVs: *1) market, 2) technical, 3) managerial, 4) regulatory, 5) internationalisation,* and *6) relational* and these are described in table 7.4 and 7.5. This study highlights that firms require a combination of knowledge for all key growth challenges that the firm faces, which concurs with the view of Marvel and Lumpkin (2007) and others (e.g. Shane, 2000) that no one single type or source of knowledge is sufficient on its own to enable small firms to capitalise on growth opportunities.

Table 7.5 Categories of knowledge acquired by cases

Coding	Category	Description of category
MK	Market knowledge	Knowledge relating to the market (such as customers or markets, suppliers, opportunities and threats, market positioning etc.)
TK	Technical knowledge	Technical knowledge required to develop a product/process/service
MngK	Managerial knowledge	Commercial knowledge required to run a business efficiently and grow the firm (such as cash flow, margins, efficient use of resources, operations planning), fundraising, corporate governance issues.
RegK	Regulatory knowledge	Knowledge associated with conforming to the strict regulation of the pharmaceutical industry such as quality standards and FDA/MHRA approval
IK	Internationalisation knowledge	Knowledge associated with working in international markets
RelK	Relational knowledge	Knowledge about how to develop links with potential partners, how to cements and manage these relationships.

Source: Categories developed from analysis of interview data

Market knowledge

Although the life science sector is a high technology industry, this study highlights the importance of market knowledge for HTNVs. Being able to successfully assimilate both complex market knowledge and the knowledge required to secure investment is crucial to company growth. It is the assimilation of market knowledge which has allowed cases B, E, F, G and I to choose their route to market and persuade investors to back their business plan. Although technical knowledge is the main input into new products and services, market knowledge is essential for understanding the dynamics within the industry and commercial exploitation of innovation. A number of cases (A, B, D, E, F, G and I) highlight links with customers and potential customers, along with other key influencers of the market as a particularly important source of market knowledge and this is expanded on below in section 7.4.3.

Technical knowledge

As all cases in this study are HTNVs, these firms were founded in order to capitalise on technological innovation. All firms can be seen to be actively engaged in developing new products and services. When the technical knowledge required to capitalise on a market opportunity does not exist within the firm, it must acquire it from external sources. Therefore, the ability to understand the value and relevance of technical knowledge from outwith the firm, and the ability to transform it into a commercial product or service, is central to their success. Technical knowledge is often explicit and publicly available through published scientific and clinical publications, or through publicly available

databases, as described by a respondent from Case E.

> *"Genbank is probably where we get all our information from. It is a public database that has every sequence that is known about a piece of DNA is in there, so you can go an look for the DNA of any virus and design a test specifically for that regions to detect it"* ER12009/28

However, firms require the ACAP to be able to utilise this highly specialised technical knowledge. Understanding and interpretation of technical knowledge, combined with the firm's existing stocks of knowledge can, in addition to enabling the creation of new technical knowledge, enable the firm to create new market knowledge. Evidence from Case E demonstrates how their prior knowledge and understanding of the market enabled the firm to combine technical knowledge with other knowledge within the firm to develop new testing services for customers. The experienced management team understood that competitive advantage lay in creating a package of quality and reliability for the customer around the testing service.

> *"You might know how to develop a test for HIV, but that doesn't qualify you to test a cell bank for HIV or human blood for HIV, because you might not put in the right controls or you might not do it under the right compliance level or that sort of stuff. All the surrounding stuff. Having the test is only part of the package. It is what surrounds the test in terms of the quality system, in terms of the way the sample comes in. the way it is booked through, the way it is recorded, the way it is reported, the way it is documented… all that stuff. The way the personnel are trained. That is what encompasses the quality."* ER1 2009/10-11

Managerial knowledge

This study also highlights the importance of managerial knowledge required for the growth of the firm such as cash flow management. As HTNVs try to balance resource allocation to support new product development or new market development, young firms discussed the positive impact of their board members in providing additional managerial knowledge to the firm, particularly when the founding management team did not possess that experience. Firms with relatively inexperienced management (cases B, D, G) discussed that they had required external assistance with corporate governance issues at the foundation stage. Firms founded by more experienced teams (cases A, F & I) did not discuss the need to acquire this knowledge, although it is evident from the discussions that this knowledge is within the firm. Firm E, despite having a very experienced management team, still drew on the knowledge of their board members to bring this knowledge into the firm.

> *"There were a lot of things… because we hadn't started up a company before, there was all of this corporate governance stuff…how you run the accounts... all of that. We didn't have a clue about that. So they made sure that you weren't doing anything illegal."* ER1 2009/28

Regulatory knowledge

The life science industry is highly regulated, and the findings from all cases highlight the need to have high levels of knowledge about the pre-requisite quality standards,

accreditations and approvals they must attain in order to operate in a given market. As the regulatory authorities in different geographies have different guidelines, interpretation of these guidelines provides important internationalisation knowledge that impacts on the internationalisation strategies of these firms. All firms providing contract research services (cases B & E) have to conduct those to Good Laboratory Practice (GLP) standards and most have MHRA(UK)[6] and FDA(USA)[6] accreditation, which requires knowledge of the regulations, but also how to successfully achieve and maintain the accreditations, as described by a respondent below.

> *"…there will be an FDA audit this year. That will happen because we are testing products from America. So that will trigger, put us onto the FDA's radar and that means that they will come over here and audit us, so we will then have been audited by the FDA, which allows you to create a higher quality statement and say that we have been audited by the FDA and they found us to be in compliance. The FDA don't issue you with a certificate. They issue you with a statement to say that you were found to be in compliance that that's it."*ER1 2009/23

All firms have expressed the fact that although the regulations are publicly available explicit knowledge, the interpretation of the regulatory authority guidelines and what it means for the company is in itself a challenge for HTNVs. How they can create a package which provides customer benefits and in turn competitive advantage is based on tacit knowledge such as know-how. Much of the tacit knowledge about the practical implications of regulatory guidelines comes from building relationships with customers.

Internationalisation knowledge

For all of the cases in this study, business development in international markets has been a central element to their business plan from inception and therefore these firms can be described as INVs (Oviatt & McDougall, 1994). However, a number of firms in this study did not consider their activities in international markets as internationalisation, but rather just as working with specific customers wherever they happened to be. As illustrated in table 7.4, these firms considered the market knowledge they required to service international markets as being simply market knowledge gained from building relationships with key players in the market.

By virtue of the specialist technical niche market that their product of service is targeted, none of the cases have had to acquire knowledge to adapt their product or services for particular international markets; they have universal applicability in all geographical markets. However, the regulatory environment is different in different markets and firms

[6] *Regulatory authorities outlined in Glossary of Terms in Appendix 3*

have had to ensure that their product or service is accredited or approved for use in those markets; therefore, regulatory knowledge is in fact closely associated with internationalisation knowledge. The understanding of regulatory authorities and the likely hurdles to be overcome to have a product approved or accredited has a considerable impact on the attractiveness of particular international markets for individual firms.

The majority of cases with products and services on the market service all international markets directly. However, despite products and services homogeneity, a number of cases (A, D, E & F) discussed having agents in Asian markets to break down barriers of language and business culture, which implies that this is important internationalisation knowledge that they need to acquire from outwith the firm.

> *"Germany is really easy to deal with. Americans are really easy to deal with as well. Asian tend to be more difficult. We need the agents there to help break that cultural difference and language barrier and that is what they do for us."* ER12009/26

Relational knowledge

This study finds that a significant proportion of the knowledge that was vital for the resolution of growth challenges was accessed through existing relationships and the building of new connections. Given the importance of partners in the exploitation of external knowledge, the knowledge about how to develop links with potential partners, how to cement these relationships and manage customers is a key component of the firm's knowledge stocks. In addition, many of the firms in this study outsource certain aspects of their activity to specialist partners. Therefore the ability to manage their supply relationships is crucial to success. Furthermore, as HTNVs are typically part of a complex value chain, understanding the firm's position in the chain and how to build appropriate relationships across the value chain is essential for the growth and development of the firm. As HTNVs tend to be at one particular end of the value chain, the lack of connections with players across the chain can lead to a significant gap in their market knowledge. In this study, relational knowledge is taken to encompass the functional knowledge of how to forge connections, as well as the contact information for key players.

7.4.3 The importance of tacit knowledge for HTNVs

Much of the external knowledge that is acquired in all cases examined in this study is tacit and not readily available or easily understood, as described by Nonaka (1994) and these findings concur that tacit knowledge can only be learned through personal experience or personal contact. This study highlights that much of the knowledge required for market development is sourced from building relationships as articulated by a respondent in case D:

> *"And a lot of the time in big pharma, there are kind of gateway people, so you've got to get to know them first and then they actually start asking for things, but they are actually going back and forth between us and the other person. You know you're getting closer when eventually the person who needs the xxxxxxxx starts getting involved. So it is about getting the message heard but also trying to build up a relationship with them."* DR12008/16

Even when specific technical knowledge or regulatory knowledge is publicly available and is therefore explicit, the valuable know-how which enables competitive advantage to be derived from the explicit knowledge is tacit. Several cases (cases A, D & E) stated the importance of knowing what the application of regulatory controls and guidelines meant for their customers, as articulated by these respondents:

> *"It's a case of printing it out [from the internet]and going through it…. But working practically with it, knowing what it means in a practical way"* DR12008/21
>
> *"It was partly understanding the way the standard worked"*AR42009/6
>
> *"… it is the way they are done. It is not unique technology, but it is the application of that technology, the way we do it, and the controls that we build around it that gives it a certain quality that clients want to come and buy." "Having the test is only part of the package. It is what surrounds the test in terms of the quality system, in terms of the way the sample comes in. the way it is booked through, the way it is recorded, the way it is reported, the way it is documented… all that stuff, the way the personnel are trained. That is what encompasses the quality."* ER12009/11

Firms discussed using such tacit knowledge to enable them to build a package around a product or service, which in itself may not be particularly unique, to give them a competitive advantage. The knowledge about customer preferences is tacit and not freely available, further demonstrating the importance of networks to make links and build relationships to gain access to tacit knowledge.

7.4.4 Which management team roles acquire what knowledge?

From the interview transcripts for each case, this study analysed the roles within the management team that were responsible for acquisition of the different types of knowledge and this analysis is summarised in Table 7.6. This study has found that in this sample, outward customer facing staff were generally responsible for the acquisition of market knowledge including market dynamics, customers' needs and preferences, competitor activity, whereas, R&D staff were generally responsible for the acquisition of technical product or process related knowledge. Operations and QA staff were generally responsible for acquisition of knowledge relating to regulatory issues and quality standards. This study demonstrates the need for different parts of the business to acquire different types of knowledge which are then disseminated and interpreted at the group assimilation phase.

> *"they [Sales] would make a judgement call. Whether they can sell it who are they going to sell it to. We might think there's this test and I think that would be applicable to this group of clients and they'll go away and maybe talk to a few and get a view [from customers] "Yeh, we want that". Or we might see from a press release and think that we need to develop a test. I would see something in the literature"* ER1 2009/31

Table 7.6 What roles within the management team acquires what knowledge?

Case		**A**	**B**	**D**	**E**	**F**	**G**	**I**
Type of knowledge (as per categories described in table 6.5)	MK	Bus Dev Dir, Mkg Mgr Chair	CEO, Sales Dir	Dir 1& 2	Sales Dir (2), CEO, Ops Dir	MD, Dir 3, Non Exec Dir	CSO	CEO, Bus Dev Dir
	TK	Bus Dev Dir, R&D Dir, Mng Dir	CEO, R&D Dir, Ops Mgr	Dir 1& 2	Ops Dir, Dir of xx, Heads of R&D groups	Dir 1, Dir 2	CSO	CEO, Bus Dev Dir
	MngK	Bus Dev Dir, Mng Dir, Chair	CEO, Fin Dir, Chair Non Exec Dir	Dir 1&2	Chair CEO	Dir 1, 2 & 3, MD	CEO, Chair	CEO, Bus Dev Dir, Non Exec Dir. Chair
	RegK	Pro Mgr, Mng Dir	CEO Ops Mgr Non Exec Dir	Dir 1&2	QA Dir Opps Dir	Dir 1	-	CEO Non Exec Dir.
	IK	Bus Dev Dir, Mkg Mgr	CEO, Com Dir	Dir 1&2	Sales Dir (2), CEO, Ops Dir	Dir 3 Non Exec Dir	CSO	CEO, Bus Dev Dir
	RelK	Bus Dev Dir, R&D Dir,Mng Dir,Mkg Mgr Chair	CEO, Sales Dir	Dir 1&2	Sales Dir (2), CEO, Ops Dir	MD, Dir 3, Non Exec Dir	CSO	CEO, Bus Dev Dir
	Abbreviations: MD = Managing Director, Dir =Director, CEO = Chief Executive Officer, CSO = Chief Scientific Officer, Com Dir = Commercial Director, Sales Dir = Sales Director, Bus Dev Dir = Business Development Director, Fin Dir= Financial Director, Mkg Mgr = Marketing Manager, R&D Dir = Research and Development Director, Ops Dir = Operations Director, Pro Mgr = Production Manager, Mng Dir = Managing Director, Ops Mgr = Operations Manager, Chair = Chairman QA Dir = Quality Assurance Director, Dir of xx = Director of a particular scientific group, Non Exec Dir = Non Executive Director, - = not discussed							

Source: Developed from cross-case analysis of interview transcripts

Analysis also highlights the importance of acquiring relational knowledge in the form of contacts and understanding how to manage relationships, in order to access tacit market knowledge.

The analysis of the acquisition of knowledge to resolve growth challenges echoes the analysis relating to knowledge antecedents in relation to the key role of particular individuals. This also highlights that when HTNVs are very small, the burden of acquiring the external knowledge required by the firm is often on the CEO and a few other key people. The firm's ability to recognise the value of knowledge is dependent on the prior experience of the members of the management team. The role of experiential knowledge as an enabler of the leverage of knowledge is discussed in section 7.8.1. The HTNVs in this sample are predominantly very small firms (see table 7.2 for employee numbers) and key members of the management team are involved in most decisions, are well connected with each other and are fully aware of the firm's objectives, which facilitates the search for knowledge to address the challenges the firm faces.

In two of the larger firms in the sample (cases A & E), respondents stated that it was all employees role to acquire knowledge relating to new product ideas and knowledge that would contribute to new product development. This is described by the following extracts from interview transcripts.

> *"they know what they need to do and they tend to bring technical knowledge in, capabilities or they might see something in the literature and highlight it to management and say look what do you think of that? And we would say that sounds like a good idea, let's do it"* ER1 2009/32

> *"Others we just pick up by reading the literature, the scientific literature. That looks like an interesting product. We check that it isn't covered by a patent, we make it, we punt it. We put it out in the market place and see what happens….Basically, it is the responsibility of all the people who read the literature and we try to encourage as much as we can for all our scientists to keep up to date with the literature."* AR12008/19

This research has already highlighted that a combination of different types of knowledge is important. This suggests that it is vital that HTNVs have the right mix of experience and connections in their management teams to enable firms to acquire the knowledge they require. This research also highlights that as firms grow in size, the management team cannot be solely responsible for the acquisition of the knowledge requirements for firm growth. However, as firms grow, the more complex management structure may create barriers or blocks to the firm's knowledge search.

7.4.5 Acquisition of external knowledge through addition of human capital

Analysis of the knowledge acquisition of HTNVs at critical events highlights that firms have recruited additional human capital as a means to leverage external knowledge to resolve growth challenges (see table 7.7). This suggests that HTNVs have a gap in their knowledge processing ability (i.e. ACAP), which cannot be plugged without the addition of human capital. For example firms that required to achieve a regulatory accreditation or gain a quality standard in order to remove barriers to entry in a particular market, recruited human capital, either in the form of consultants (cases A, B & F) or by recruiting experienced staff (cases A & B). Cases B, D & F discussed the recruitment of sales and business development staff to enhance their ability to grow sales in new markets. Firms have also recruited technical specialists (cases A, B & D) to assist with new product and service development in an area which has been identified as a market opportunity but the firm does not have the required knowledge internally. Furthermore, a number of firms (cases A, B, E, F, G & I) can also be seen to recruit experienced individuals to their board to facilitate the response to the challenges the firm is facing.

Table 7.7 Leverage of knowledge to resolve growth challenges via recruitment

Growth challenges associated with identified critical events	Human Capital recruited as a means to acquire new knowledge											
	Chairman	CEO	New Board members	Finance Director	R&D/technical staff	Sales Director/Business Development staff	Scientific advisory Board	Operations Manager/Ops staff	Supply network manager	Managing Director	QA staff	Regulatory /QA consultant
New product /service development (Product innovation)					A,B	B	G					
New market sector development (Market Innovation)	A, G	G	B, F		B	B,D	G	E		F	A	
New international market development (Internationalisation & Market innovation)	A		I, F			B				F		
Sourcing collaboration partners (Innov)												
Investment in new production facilities /increasing capacity/ efficiency (Process Innovation)				B				B, E			A	
Attaining quality standard/ regulatory authority accreditation or approval/adhering to regulatory guidelines (Process and product innovation)			B,I					B, E			A	A,B, F
Raising finance (Entrepreneurship)	B, E, I		B	B								
Sourcing supplier/outsourcing partners (Innovation)			I						B			
Ventures A-I – case firms that discussed recruiting human capital to acquire knowledge to resolve growth challenges												

Source: Developed from cross-case analysis

Table 7.8 Examples of investment in human capital and types of knowledge acquired

Case	Recruited human capital	Resulting external knowledge acquired
A	Chairman QA staff Technical specialists Regulatory consultant	MK, IK, MngK, RelK RegK, TK TK RegK
B	Sales Director and Business development staff QA Consultant Operations Manager Financial Director Supply Network Manager R&D Director Chairman New board members	MK, IK, CK, Rel K RegK, TK, TK, CM, RegK, MK MngK MK, IK, TK, RelK TK MngK, RelK MngK, RegK, IK, RelK
D	Business Development staff	MK
E	Operations staff Chairman Board members	TK, MK MgtK, RelK MgtK
F	Managing Director Regulatory consultant Board members	MK, MngK RegK MK, MngK
G	CEO Chairman Scientific Advisory Board	MngK, MngK, MK, RelK TK
I	Chairman Board members	MngK, RelK MK, MngK, RegK, IK, RelK
Types of knowledge: TK = technical knowledge, MK = market knowledge, MngK=managerial knowledge, RegK = regulatory knowledge, IK = Internationalisation knowledge, Rel = Relationship knowledge		

Source: Developed from cross-case analysis

In firms that operate more of a virtual model (Cases D & I), and have not recruited human capital can still be seen to be bringing the knowledge they require to the firm by outsourcing certain activities. This process of outsourcing to experts allows the firm to learn and enhance their knowledge.

The addition of human capital with appropriate experience therefore adds to the ACAP of the firm, by enabling further external knowledge to be acquired by these individuals. The knowledge that the firm has acquired through these individuals is summarised in table 7.8. There is also evidence that the social capital of newly recruited human capital can have a significant impact on the firm's ability to leverage external knowledge. The importance of social capital as an enabler of the leverage of knowledge is explored further in sections 7.8.2 and 7.9.

7.4.6 Sources of external knowledge for HTNVs

Table 7.9 analyses the sources of external knowledge for the HTNVs in this study with a view to judging the diversity of exposure to external knowledge. The diversity of exposure to a great variety of knowledge sources suggests that firms are outward looking and proactively scan the environment for appropriate knowledge to acquire. Sources range from publicly available explicit information such as guidelines from regulators, scientific journal and patents, to highly tacit know-how from collaborators and in-depth knowledge about customer needs and preferences. A number of researchers have suggested that the diversity of exposure and the degree of overlap between the knowledge bases of the external sources and the firm can enhance the firm's ACAP and ability to acquire knowledge (Cockburn & Henderson, 1998; Lane & Lubatkin, 1998; Matusik & Heeley, 2001; Zahra & George, 2002b).

This study also highlights the importance of customers as a source of market knowledge. It is evident that building links with key players in the industry in order to gain access to tacit market knowledge about the needs and requirements of potential customers, is a key activity that builds market awareness.

> *"we are of the great belief that nothing will be developed unless the client want it, so our R&D meetings include myself [Sales Director], which is also quite rare, but we don't want the R&D team to go off on a route of great scientific interest if there is no commercial interest."* BR22009/26

Although regulatory guidelines are explicit, the individual product approval requirements are specific and therefore, tacit regulatory knowledge to assist with product development that can only be acquired through the relationships built with customers, as demonstrated by an example from a respondent from firm E:

> *"…customers are a continuous feed of the knowledge. They are the people who are constantly communicating with the regulatory authorities. To get their drug on the market. So at every meeting they [the regulatory authorities] say you should do X Y and Z and they [customers] come to us and we do it. So they feed us a lot"* ER1 2009/29

Suppliers were also highlighted as an important potential source of knowledge by cases B, D and I, highlighting the importance of choosing wisely when outsourcing key activities as described by a respondent from case I:

> *"as you work through that process and you want the people who are completely on top of their game. You don't want the surgeon who has done something once or twice; you want the surgeon that is doing dozens of these every week. In working with people who have expertise, you pick up a lot of knowledge from them and that is why we are keen to do other projects. We have learned a huge amount as we've gone through."* IR12010/23

Table 7.9 Sources of external knowledge and the type of knowledge acquired

Cases within this study			A	B	D	E	F	G	I
		T/E	Types of Knowledge						
Sources of external knowledge consulted	Market research reports	E	_	MK	-	-	MK	-	MK
	Commissioned market research	E	MK	MK	MK	MK	MK	MK	MK
	Scientific Journals	E	TK	TK	-	TK	-	TK	TK
	Trade press	E	-	MK	-	MK	-	-	-
	Patents	E	TK	-	-	TK	TK	TK	TK
	Scientific /academic conferences	E&T	TK, MK, RelK		-	TK, MK, RelK	TK, MK, RelK	TK, MK, RelK	-
	Industry conferences/Special Interest Groups	E&T	TK, MK, Rel K	TK, MK, Rel K	TK, MK, RelK	TK, MK, RelK	-	TK, MK RelK	-
	Academic contacts	E&T	TK, MK	TK, MK	TK	TK	-	TK	-
	Industry contacts	E&T	TK, MK, Rel K	TK, MK, Rel K	TK, MK RegK, RelK	TK, MK RegK, RelK	TK, MK RelK	TK, MK RelK	TK, MK RelK
	Retailers/Distributors	E&T	IK, MK,RelK	-	-	-	MK, RegK, RelK	MK, RelK	
	Agents	E&T	MK, IK, RelK Japan	MK, IK, RelK	MK, IK, RelK Japan Israel	MK, IK, RelK Asia	MK , IK, RelK Asia	-	-
	Customers/potential customers	E&T	TK, MK, RegK, RelK	TK, MK, RegK, RelK	TK, MK, RegK RelK	TK, MK, RegK, RelK	MK, TK, RelK	MK, TK, RelK	MK, IK, RegK, RelK
	Suppliers	E&T	-	TK, RegK, RelK	TK, RegK, IK, RelK	-	TK	TK	TK, MK, RegK, RelK
	Collaborators	E&T	-	-	TK, MK,RelK	TK, MK	TK, MK	TK, MK	TK, MK, RegK, IK
	Competitors	E&T	MK	MK	-	MK	-	MK	MK
	Regulatory authorities/QA standards	E&T	RegK	RegK	RegK	RK	RegK	RegK	RegK
	Consultants	E&T	RegK	RegK	MngK	-	RegK	-	-
	SE* account manager	E&T	-	MngK	MngK	MngK	-	-	-
	SDI*	E&T		IK, RelK					
	LSBAS* adviser	E&T	-	MngtK	MngK	MngK	-	MngK	-
	Mentor	T	-	-	MngK MK RelK	-	-	-	-
	Internet	E	TK, MK	TK, MK, RegK	TK, MK, RegK	TK, MK, RegK	-	-	TK, MK,
	Trade association	E&T	MK, RelK	-	-	-	-	-	-
	Networking groups	E&T	RelK	RelK	RelK	RelK	RelK	RelK	-

Types of knowledge acquired: MK= Market knowledge, TK= Technical knowledge, MngK = Managerial knowledge, RegK=Regulatory knowledge, RelK= Relational knowledge, T = tacit, E = Explicit
*=Abbreviations in Glossary of Terms in Appendix 3

Source: Developed from cross-case analysis of interview transcripts

Given the extent of tacit knowledge acquired from the various sources of knowledge, this emphasises the importance of building relationships with individual contacts. When asked to describe how the firm sourced the knowledge they required to resolve the challenges they faced at critical events, a number of respondents stated that they knew where to get knowledge they required through their previous experience in the industry. Their experience and connections in the industry meant that they knew where to look for solutions, or who to ask to point them in the right direction. Firms can be seen to be saving time and resources by efficiency of searching for knowledge by using industry connections. The social capital of HTNVs and the impact on the firm's ability to acquire external knowledge is explored in the next section.

7.4.7 The importance of social capital as an enabler of knowledge acquisition

This study demonstrates the importance of social capital to enhance the firm's ability to leverage knowledge. When discussing the source of external knowledge that was acquired to transition through growth challenges, all respondents noted the importance of links and connections for their firm, such as described by a respondent in Firm D:

*"a service based organisation is purely dependent on your links, networks and contacts"*DR12008/12

This study provides evidence that suggests that social capital acts as an important enabler for HTNVs to increase their ACAP and their ability to leverage knowledge. Indeed social capital, for HTNVs that often do not have experienced management, could be as important as prior knowledge and experience for the firm's ability to leverage knowledge. The old saying "It's not what you know but who you know" can be seen to be very applicable. By knowing how to access knowledge through building relationships, HTNVs can cost effectively access knowledge they require without having to build that knowledge within the firm. The findings from this study also suggest that knowledge acquired from trusted sources such as relationships and connections, is recognised by firms as having more value, thus social capital enhances the ability of firms to recognise the value of external knowledge.

HTNVs in this study are small and have limited resources to buy market research. In addition, as these firms operate in a business environment where their product is often first to market, they are often creating the market and therefore market research is not available. This study finds compelling evidence that social capital is important for acquisition of tacit knowledge that is not readily available through other sources, in order to build market awareness. Therefore, developing relationships with key players within the industry, while their technology is in development, is an important means to acquire new market knowledge to facilitate new product development, product positioning and making decisions about the most appropriate route to market. For HTNVs, there may be a trade-off between the benefits of knowledge sharing in relationships and the risk of leakage of key knowledge assets. Although relationships are an essential for accessing tacit market knowledge, the relationship may have to be formalised in order to enable both parties to realise the growth benefits of the relationship (see section 7.7 and table 7.13). The types of relationships found to be important to the acquisition of external knowledge, and the types of knowledge they provide, are summarised in table 7.10 and can be categorised as follows:

1. Business Links: a) existing business links, b) new business links, c) links with gatekeepers in key large companies, and d) local business networks
2. Academic links
3. Specialist interest groups (which can span categories 1 and 2)
4. Links of the Board
5. Personal links
6. Links with policy makers.

These are explored in more detail in the following pages.

- *Business Links*

This study finds that business links are a key source of tacit market knowledge that build market awareness. However, as HTNVs operate in niche globalised industries where market opportunities are technical specific and heavily regulated, business links also provide technical, regulatory and international knowledge.

a) *Existing business links* made prior to the foundation of the firm were found to be one of the most important source of external knowledge to the firms in this study. As a number of HTNVs in the sample were founded by individuals with significant experience in the life science industry, business links, developed in some cases over decades, were a source of tacit market knowledge. Business links also provided case firms with technical, commercial, regulatory and international knowledge. In many cases, the knowledge acquired from these trusted links was highly valued and gave the founders the confidence to found the firm. Where existing business links are with potential customers of the new firm's products and services, these connections are often the first customers of the new firm. Furthermore, these business links are often international.

> *"We had client connections, the clients knew us. A lot of the clients work with the person. If the person is associated with a good operating system that is a high quality product they will work with the person because it is a scientific service for contract research they know that doing research, you know that people like to do research certain ways… they like working with specific people, so we had clients contact us as soon as they knew what we were doing, they contacted us and came here."* ER12009/16

> *"The Japanese agent, we had that before the firm was formed. We had loads of contacts in Japan, the US and Europe which we followed up"* DR12008/11

b) From the analysis of how HTNVs acquire knowledge suggests that firms perceive *new business links* to be important to foster. All firms can be seen to be proactively developing new business links with potential customers of their products and services. Although much of the new product development for HTNVs is still far from market, firms are developing and cementing relationships while they are developing their product and services. Developing links with potential customers is particularly important. In the case of firms developing innovative products (cases F, G & I), although the firms are founded on the technological innovation, mapping the route to market and building relationships with distributors and development partners is crucial to commercial success of these innovations, as described by a respondent from firm G:

> *"the knowledge that xxx[founder] has built up being in the market. We know who the principle players are in the market to whom we should be talking and we already are."*GR22009/26

The presence of existing links in the pharmaceutical industry, even when they are not in an area that is helpful to the firm's current knowledge requirements, enables the creation of new links, as described by a respondent from Firm I.

> *"…so we had limited contacts and we had certainly not done any manufacturing work before and no development because we were sales and marketing guys so all those connections we had to create and forge. But we had been in the industry a while. We understood the importance of developing and maintaining relationships and that is what sales is about. So we understood that we needed to get them and once we got them to be able to look after them."* IR12010/13

c) Developing links with *gatekeepers to customer internal networks* is an important source of knowledge acquisition. HTNVs in the life science industry are often part of a complex value chain where they sell products and services to much larger companies and accessing appropriate contacts within these vast complex organisations with up to 100,000 employees that might use their services is a challenge. Although pharma all have their business development departments that act as a formal gatekeepers into the firm, it tends to not be the most effective route for companies to get business due to the volume of opportunities that the business development function get presented with. The key to being able to provide a service to pharmaceutical companies is understanding what research they are working on and the problems they are encountering, and the customer's specific requirements and motivations. This knowledge is not readily available and will only be shared with trusted contacts. Therefore by building links with scientists in pharmaceutical and biotechnology companies, and by being seen as a helpful expert that can provide solutions, firms can get a window on the inner workings of these large companies and win business. Firm D describes building a relationship with a key representative from GSK who has been instrumental in winning repeat business.

> *"I contacted a few people, I had email addresses that I had semi dealt with before but not directly. And I eventually got put through to the guy who is responsible for xxx for all of GSK. So I went to see him and we were both really excited that we had got into GSK. And basically it was different people round the table from different groups all interested in xxx and we have done work with a few of them since then, so you can really trace it back."* DR12008/13

A year later, the firm describes how trust has been developed between the firm and this large company to the point where the gatekeeper no longer needs to be involved.

> *"that has been pivotal meeting. It had been great. Even the guy who organised for me, he has since been made redundant and has moved onto another company, but the xxxx man that I met there that runs xxx stuff for the whole of GSK in Europe. I'm still in contact with him quite regularly…….now he has let me… we did some project management stuff for some of his staff. And he said "look I don't need to be on the call, xxx [case D]can do it" Which is quite nice, you know."* DR12009/8

Table 7.10: Summary of knowledge acquisition from the social capital of HTNVs A – I

Types of social capital/ knowledge acquired			**Domestic/International**		**When made**		**What knowledge**					**Tacit/Explicit**	
			Domestic	International	Pre-found'n	Post found'n	TK	MK	MngK	RegK	IK	Explicit	Tacit
Types of social capital	Business links	Existing business links	ABDEGI	ABDEFGI	ABDEFGI		ABGI	ABDEFGI	ADF	EI	AF	BGI	ABDEFGI
		New business links	BE	ABDEI		ABDEI	ABI	ABCDEHI		BI	I	A	ABDEI
		Gatekeepers and the internal networks of large companies	EBD	ABDEI	E	ABDEI	BD	ABDEI		ABDEI	D		ABDEI
		Local business networks	ADEGI			ADEGI	G	DEG	AI			EGI	DEGI
		Links with potential suppliers	BDF	BDFI	DIF	BCDI	BDFI	BDFI	BF	BCI	BI	I	BDFI
		Developing links with collaborators	ED	CG	DEG		DEG	DEG	DG	D		E	DEG
	Acad / Bus	Specialist interest networks/groups	G	AEG	G	AEG	G	AEG		E		EG	EG
	Academics	Academic contacts (local)	ABCEG		ABEG	A	ABEG	ABEG				ABEG	ABEG
		Academic contacts (International)		ABCG	AG	AB	ABG	ABG				AG	ABEG
	Board links	Links of Chairman	BI	AG		ABGI		ABGI	BI	BI			ABGI
		Links of Board Members	F	BI		BFI		FI	I	BI	I		BFI
		Links of investors	EF	F	F	EF		F	E	F	F	F	EF
	Other	Personal links	ADF	F	AF		AH	AF	A		F	D	AF
		Links with policy makers	B	B		B				B		B	B
		Cases A-I = high technology new ventures in this study Types of knowledge : Explicit/Tacit (Nonaka, 1994) Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=Managerial knowledge, RegK=regulatory knowledge, IK= Internationalisation knowledge											

Source: Cross-case analysis. Note: When discussing critical events for the firm and the knowledge acquired to transition growth challenges respondents discussed these links as sources of knowledge.

d) All firms in this study are well connected with other firms in the local life science cluster through *local business networks*, such as Nexxus and Connect. Although the majority of the links developed locally provide managerial knowledge, such as interesting insights into how other firms deal with particular human resource issues; there is evidence to suggest that firms have acquired market knowledge from these links, finding both local customers (case D) and suppliers (Case G) that they were not previously aware of.

- *Academic links*

Academic links that keep the HTNVs in this study at the forefront of scientific advances tend to be international. This reflects the fact that there are clusters of particular expertise in particular locations around the world due to the local stickiness of technical knowledge (Saxenian, 1994; Ernst, 2002). Local academic links are only maintained if there is a particular pool of expertise that the firm finds to be of value. Scotland has a strong academic life science cluster, so a number of firms (cases A, B, E, G) have maintained their links with local academic research groups.

These links enable the firm to acquire technical knowledge, resolving technical challenges, accessing the use of highly specialist equipment. Often the knowledge that these links provide access to will in time be explicit knowledge publicly available through scientific journals. However, these academic links enable the firm to gain preferential access to the knowledge in advance of the rest of the market. In particular, the interpretation of technical knowledge from trusted sources provides the firm with market and technical knowledge, such as the clinical applications of technological advances. Furthermore, where firms provide products and services to research laboratories, these links can also become customers.

- *Special interest groups*

A number of firms suggested that the forging of links through becoming part of a *special interest group or network* was an important source of market and technical knowledge to build market awareness. Both customer facing staff and research staff attend specialist technical conferences and join special interest groups to build links and cement relationships with scientists from their potential customers and academic research groups.

Firm A describes meeting industry scientists at conferences, where the scientists in the firm build links with research scientists in pharmaceutical companies. These relationships enabled firm A to recognise an emerging opportunity.

> *"Some of the triggers were statements made by companies themselves at conferences. That's another place that we get information, by attending the meetings that take place in this area. One of the things that was a real trigger… There used to be a perceived dogma that what you did was kept your molecule simple. Keep the molecule simple and it will be cheaper to manufacture, easier to manufacture, low cost good, means better products, easier to make, higher margins etc. There was a time when there became a change which was a distinct change in that message that was coming across….What's more important was a good activity of the molecule and designing the molecule to have the maximum efficacy, so that it is a more powerful molecule that you need less of. So, it doesn't matter how much it costs. It may cost more, but if it is much more effective, then it's going to be the better molecule. So, a second and third generation set of these oligonucletides started to appear that had more complexity and that for us was the signal that we would have a role to play….You were starting to get these speciality things that were added into the molecule."* AR12008/25

In some cases where the market is very immature, the technical networks and special interest groups that include academia and technical specialists from industry are the most useful means to understand the readiness of industry to adopt innovations. These networks provide access to the key contacts in industry that are interested in these innovations and the firm, by being seen as an opinion leader, gain the trust and respect of potential customers. Having access to the appropriate knowledge is a key factor as described by a respondent in Case G

> *"It is knowledge that I have just acquired, because I was in contact with xxxxxx network[links with academia and industry]"*GR12009/26

These findings reinforce the earlier work of Powell et al. (1996) who showed that being part of a special interest group where people discussed common interests through a shared cognition, increased the firm's ability to access people and their information. The weak ties forged through this route were often formalised to enable further knowledge transfer to occur (see section 7.7)

- *Links of Board Members*

Six of the seven cases in this study have a Board of Directors. A number of firms (cases A, B, E, F, G & I) note that the links of their Board, including their Chairman, other board members and investor representatives brought useful external knowledge to the firm as a result of their networks and links. This study finds particular evidence (cases A, B, E, G & I) that a well-connected chairman is able to draw on their relationships to assist the firm to quickly acquire knowledge to resolve specific challenges facing the firm. For example, Chairman used their connections to recruit other board members who in turn enable the firm to acquire further knowledge they require for the growth of the firm. The majority of

cases had made changes to their board to bring new members onto the board that had the expertise and connections to address specific challenges the firm was facing. Board members also used their links to assist recruitment of suitable candidates with specific skills sets for vacancies. None of the firms reported that board member links provided technical knowledge, although one firm has a scientific advisory board to assist with the applications of the technology. The main types of knowledge provided by the links of Board members were market, managerial, regulatory, and international. Furthermore, this study also demonstrates the value of specialist sector specific investors who are well connected within the industry and have a wealth of contacts that can assist small high technology new ventures. Having well connected investors on the firm's board can provide access to knowledge, as described by Firm F:

> *"We chose the funder xxx because they were well networked in the life sciences side of things and had contacts to retail. So for example, we've been struggling with the FDA and you know it took us a while and we put our sales strategy together, and again they[investors] have experts/ colleagues that they use .. colleagues that advise their other clients and have been wheeled in from time to time"* FR12008/23

These findings suggest that the social capital of board members can be particularly useful means for HTNVs to enhance their ACAP, and increase their ability to leverage the knowledge they need to resolve growth challenges.

- *Personal Links*

In contrast to other studies that point to the importance of family connection, this study does not find that personal relationships are of significant value to HTNVS, when compared to other types of social capital. This is possibly due to the nature of high-technology markets. However, there is evidence that building personal relationships within the sector, whether in industry or academia can be seen to be beneficial. Founders used trusted personal relationships to discuss business ideas and to do initial evaluations of market opportunities, which in one case led to a contact mentoring the founder through the foundation of the firm. For example firm D utilised a personal contact with many years of experience in the industry to sound out ideas about company foundation.

> *"I've known him for years when I used to work for them. I basically had lunch with him and sounded him out. He basically pointed us in the direction of LSBAS."* DR12008/9

Firm F recruited an agent for the Asian market through a personal university friend of one of the founding directors. In case E, the knowledge about the capabilities of an organisation, which the firm now collaborates with to provide a joint service, were brought

into the firm through a link that a Director had maintained with the academic network from doing his PhD.

> *"That [the collaboration] originated from xxx [a founding director]. xxx [founding director] did his PhD in xxx [research institute]."* ER1 2009/21

- *Links with policy makers*

Firm B has a proactive strategy of building links with regulatory authorities to try to influence their development of new guidelines that could impact favourably on their business. It also aims to influence policy regarding the availability of supply of certain high value consumables in the UK. This is evidence of the strategic development of links as a first step to address growth challenges in the firm.

Although this section only highlights the role of social capital on the acquisition of knowledge, the wider impact of social capital on the leverage of knowledge to resolve growth challenges is explored further in section 7.9.

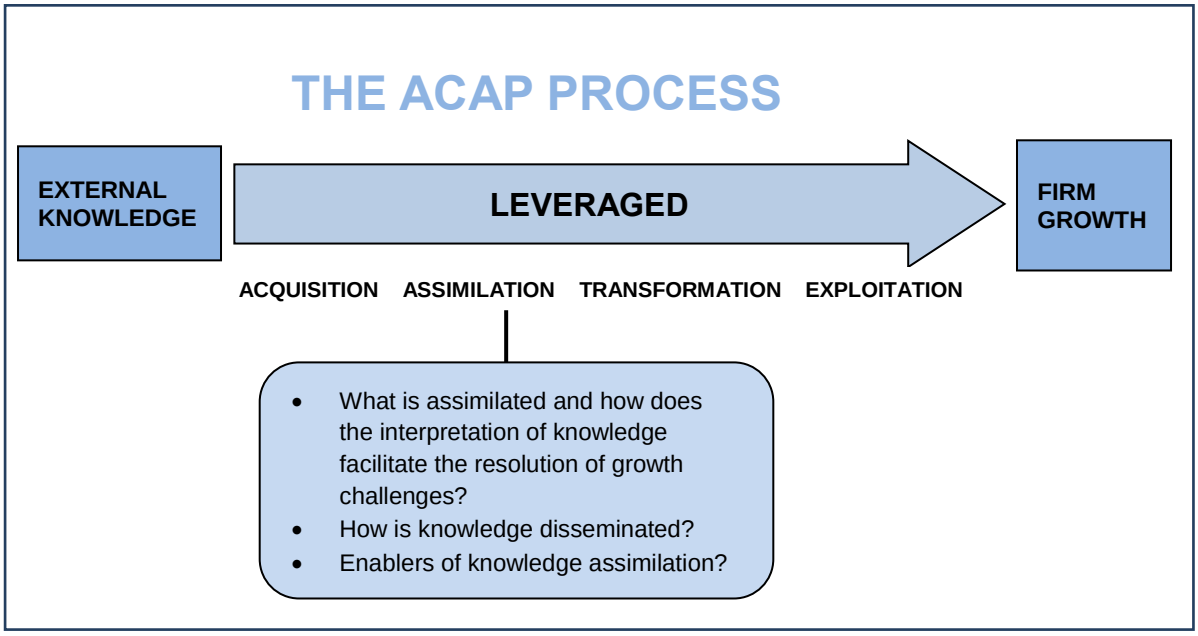
7.4.8 Summarising enablers of acquisition

It is evident from the findings of this study that in addition to social capital, there are other key enablers of knowledge acquisition, including prior experience, market awareness, the extent of the search for knowledge. These are each discussed in detail in section 7.8, but the acquisition dimension suggests that all of these enablers are interconnected and work synergistically, rather than have a beneficial effect in isolation.

7.5 Assimilation of external knowledge by HTNVs

Assimilation of knowledge, as described in Chapter 3, refers to the routines and processes that enable firms to analyse, process, interpret and understand information from external sources (Kim, 1997a, b; Szulanski, 1996). Assimilation of knowledge involves the firm interpreting and understanding what the knowledge they have acquired means for the firm, and is an essential step in the leverage of knowledge. This section of the chapter discusses the findings of this study with regards to how external knowledge is assimilated to facilitate the resolution of growth challenges associated with critical events. Firstly, this section investigates what is interpreted by firms from the knowledge they have acquired, examining how the assimilation of external knowledge assists with resolution of some of the challenges the firm faces. Next, the process of assimilation as described by the case firms is outlined with the aid of visual maps. This study finds evidence that suggest that knowledge is initially assimilated by individuals. A key element of a firm's successful understanding of the implications of external knowledge involves the effective dissemination of knowledge by the acquirer to the appropriate parts of the organisation. Therefore this study outlines the knowledge flow within the firm and the routines by which

Figure 7.3 ACAP as a research lens - the assimilation dimension



Source: Developed by the researcher adapted from Zahra & George (2002b:192)

external knowledge is communicated throughout the firm. Furthermore, this study finds evidence to suggest that knowledge is then assimilated by relevant teams, who aid collective interpretation of what the new knowledge means for the firm in view of the challenges the firm is facing. This study provides significant evidence that both social capital and experiential knowledge have a significant impact on the capability to assimilate external knowledge.

7.5.1 What knowledge is assimilated?

The HTNVs in this study can be seen to acquire and interpret a considerable amount of external knowledge in key areas which impact on the firm's ability to resolve growth challenges. Table 7.11 summarises the knowledge that is assimilated and how this additional understanding is linked to challenges the firm faces. These issues can be

Table 7.11 Cross-case analysis of the types of assimilated knowledge

			Ventures A-I						
	Knowledge assimilated		A	B	D	E	F	G	I
Challenges faced	New Product development	Evaluating new product/service development opportunities	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Prioritising new product development in relation to other scientific and commercial value	Yes	-	-	Yes	-	Yes	Yes
		Understanding customer behaviour, needs and preferences	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Likelihood of adoption of product or service	Yes	Yes	-	-	Yes	-	Yes
	Market development	Understanding industry dynamics and the firm's position and influence in the industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Evaluating new market development opportunities	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Barriers to entry	Yes	-	-	Yes	Yes	-	-
		Estimating potential market size/demand	Yes	Yes	-	-	-	-	Yes
	Int	prioritising geographical market to enter	Yes	-	-	Yes	Yes	Yes	Yes
		Evaluation of routes to market/distributors	Yes	Yes	Yes	-	Yes	Yes	Yes
	Reg	Understanding the impact of regulation in the industry	Yes	Yes	Yes	Yes	Yes	-	Yes
	Int= Internationalisation, Reg= Regulatory accreditation/approval								

Source: Cross-case analysis. -= Not highlighted by the firm

aggregated according to the growth challenge solutions they help provide as follows: a) new product development (evaluation of new product development opportunities, prioritising new product development based on the scientific and commercial value of

innovations, understanding customer behaviour and requirement; understanding what is of value to customers, understanding the likely adoption of a product or service); b) new market development (understanding industry dynamics and how the firm positions itself within it, evaluating new market opportunities, estimating market demand, understanding barriers to entry, evaluating routes to market), c) internationalisation (international market selection) and d) the firm's interpretation of regulation in the industry. As it has already been highlighted that the challenges facing HTNVs are interwoven, there is also evidence that the assimilation of knowledge can contribute to the resolution of multiple challenges.

a) Assimilation of knowledge in relation to new product development

Examples of the assimilation of knowledge in relation to new product development are outlined in the next couple of bullet points:

- *Prioritising new product development based on the understanding of scientific and commercial value of innovations*

Evidence from four cases is this study (A, E, G, I) suggest that HTNVs prioritise new product development opportunities on the basis of assimilating external knowledge about the potential for innovations other innovations in the field. The assimilation of market and technical knowledge has enabled case G to select the first product to take to market, with a focus on making a quick return on investment.

> *"It is a focused range of applications, so initially what we are doing is focussing the first assay kits, we have a lot of data to support it and the first one is the easiest one to get to market"GR22009/17*

- *Understanding customer behaviour and requirements aids developing product attributes*

This study finds evidence to suggest that when bringing a new product to market that will potentially displace others, understanding current customer practice and what the requisite change in their behaviour would be is key to commercialising an innovation in a way that maximises adoption by the market. For example, in case G assimilation of current practice and the extent of the change in behaviour that customer will have to make in order to use your product, is combined with a prediction of whether the firm with its limited resources can influence the market sufficiently for the product to be a success. Assimilation of

market knowledge enabled firm G to make decisions about positioning and the appropriate route to market for their lead product.

> *"Basically, I've been going round conferences talking about this for 10 years, but the problem is that the veterinary practice hasn't been able to access the test using the tests that they use. The kits haven't been available so that any vet can send his sample to his regular laboratory and … first of all they don't like a chain of laboratories, they don't like splitting the sample……Because we are a small player and it is a very fragmented market, we might not have the resources to influence the market so we want to work with a big player who's got the ability to firstly inform the market. Because, we need to influence the vets of its effectiveness as well. So, it's an education and the influencing of vets, you should really be trying this test."* GR22009/13

Assimilation of technical and market knowledge in case G allows the firm to understand the product development issues they need to resolve in order for their product to fit within the current market of veterinary tests.

> *"…there are only minor variations to the kit for different types of analysers. They do have their own operating procedures but they are doing the same function, so we do have to make some tweaks to kits there so that's why it is important for us to do in-house testing on the most common types of analysers"*GR12009/35

When developing innovative new products and services in immature markets, market research is not readily available. Assimilation of the fact that there is limited market research has encouraged firms to use prototype products and services to test the market directly. Feedback from customers about the new product enables a number of cases (A, B, E, F & G) to evaluate the likelihood of whether there is demand for the product/service.

> *"So you would have to do market research completely from the first principles market research, It is not the case of a product that you can look at. You can't look at the market for toothpaste, you can say it x millions and we'll get a certain percentage of that is worth so and so. It's really down to phoning people around and it starts to get expensive, so expensive that it is cheaper to use the product itself to see if there is a market so that is a technique we use a lot"* AR12009/2/2

The assimilation of customer feedback as an important means to understand customer preferences highlights the role of social capital in assimilation of knowledge

- *Understanding what is of value to customers enables service development*

Understanding what is of real value to customers is key to ensuring that products and services developed will create a competitive advantage for the firm. Firm E has assimilated tacit market and regulatory knowledge from customers that has enabled the firm to develop a service offering that gives the firm a competitive advantage.

> *"It is the high quality, high technical quality of the product and the fact that that product is surrounded by a high quality control, quality assurance, operating system which gives the client a high degree of confidence that they can outsource the test and they won't have any problems."* ER12009/11

Assimilating specific customer requirements as relationships develop with customers is also important. This enables the firm to get a better understanding of the needs of a

particular industry sector, enabling the firm to better position itself to service these requirements.

b) Assimilation of knowledge in relation to new market development

Examples of the assimilation of knowledge in relation to new market development are outlined in the next couple of bullet points:

- *Understanding industry dynamics and how the firm positions itself within it.*

This study finds that in a complex diverse industry such as life sciences, it is essential that HTNVs developing new products (cases A, B, F & G) understands the dynamics of the particular industry sub-sector the product is intended for. Equally, for specialist service firms (cases A, B, D & E) their service fits into a value chain and understanding the industry dynamics is as important as the development of the service. This study provides evidence that a key element of assimilation of external knowledge is understanding the key players in the industry that might be potential customers or be in a position in the value chain to influence buying behaviour of customers, as described by case G:

> *"So we know what they need, we know what the market benefit is, therefore we know what the potential need is in terms of the owner, the vet, the commercial lab. We can see how they will make money out of it because this is just an additional test that they will add on to a routine bank of tests that they will be doing, so there is no real… the incremental cost to the laboratory is very modest. It doesn't require any change in behaviour or practice, based on their existing equipment. So we have this knowhow and the knowledge that xxxx[founder] has built up being in the market….. We know who the principal players are in the market to whom we should be talking and we already are."*GR22009/26

This is critical to effectively developing relationships that can impact on the growth of the firm.

- *Evaluation of new market development opportunities*

This study finds that all the HTNVs have utilised assimilation of market knowledge to evaluate a number of potential commercial applications for the technological innovations they have developed. For example, a potential future market opportunity for case A comes from the anticipated introduction of personalised medicine, where therapeutic drugs will only be licensed by the regulatory authorities if they have a corresponding diagnostic kit which indicates the particular subsections of the population that will benefit from the particular medicine. Assimilation of technical and market knowledge in relation to the

commercial applications of the mapping of the human genome suggest that the increased use of diagnostics may provide new product opportunities for the firm.

> *"Drugs will eventually come with a diagnostic kit that will say you should administer this drug to this person because of their genetic profile… So there will be pieces of DNA that find particular genes in a set of patients and say that set of patients should receive this drug, this set should receive that drug and those should receive the other and those shouldn't touch it at all because it would do them lots of harm."*AR12009/2/12

Faced with a number of potential market opportunities, successful assimilation of external market and technical knowledge is key to understanding what an individual market opportunity means for the firm and whether it is worth entering that particular market. Case A describes its assessment of the potential niche market, anticipating small sales, however due to the specialist nature of the product, anticipating the likely margins to be high, making it worthwhile entering.

> *"What the diagnostic people will require is more sophisticate molecules more complex molecules manufactured on a much smaller scale . They'll be talking about kilogram scale as opposed to multi hundreds and thousands of kilograms at a time, so it is a scale question and a complexity question. It is a smaller scale but the molecules themselves are more sophisticated so barriers to entry will be higher, the cost of the materials will be higher, because they are more sophisticated, and the margins will be higher."* AR12009/2/12

Firm A's technical capability is able to meet the needs of this market, but assimilation of regulatory knowledge, enables the firm to understand that as this market has different regulatory standards, it will have to adapt its quality standards to comply with the different regulatory standards in this market.

> *"We have to adapt again to a slightly different set of standards and requirements. The diagnostics industry has its own standard. In fact, it doesn't manufacture to GMP. It manufactures to a different ISO standard."* AR12009/2/13

Assimilation is an essential step which enables the firm to understand what the market knowledge means for the firm, prior to the transformation step where a company decides whether to make an investment in developing additional quality systems that would remove the barriers to entry in this market.

- *Estimating market demand*

This study finds that estimating market demand is a key element to evaluating potential new market opportunities for the sample HTNVs. For example, Case I demonstrates that in markets where there is no existing product, forecasting future sales demand is a complex process of assimilation of knowledge from a variety of sources.

> *"…you have to understand the market the dynamics of the market, how many patients present every year, how many of them get product x, product y and why would they get your product rather than what they are on at the moment?"* IR12010/22

> *"…in a market where you haven't launched before, you just have to understand what the sales are, what the market size is, how medicine is currently practiced, how you are asking medicine to change, for prescribers to change what we are asking them to do. What groups of patients have been identified, what size that group of patients is, how that group of patients are currently managed, whether that is good, bad or indifferent. Also, what*

> *the differentiator with your product and why you have a persuasive argument as to why it will be adopted, what the adoption uptake will look like. So that is what we do with those guys. We sit and brainstorm and gather all the information together, put it in a big spread sheet and what you end up with is a sales graph: an optimistic one, an OK one and a pessimistic one. It is a sophisticated guess. That's forecasting for you"* IR12010/23

The ability to interpret current trends and to predict future prescribing behaviour comes from significant prior experience of launching new medicines.

> *"We've got a lot of experience we've been in the pharmaceutical industry. xxx[Founding Director] and I for north of 50 years now and we've worked in lots of different therapy areas we know what it is about medicine that make them attractive"* IR12010/12

Similarly, case B demonstrates the effect of assimilation of feedback from customers on estimating future market demand. Assimilation of the results of initial prototype testing with customers in industry revealed that pharmaceutical companies are unlikely to invest in equipment that they didn't see as a necessity. Assimilation of this market knowledge direct from customers, enabled the firm to understand that when bringing a disruptive technology to market, there has to be a compelling reason for customers to change their behaviour. Assimilation of further market knowledge facilitated a decision to change their focus to a service based model, which has enabled the firm's growth.

> *"Quite amazing that they were very conservative albeit that there were a number of demonstrations that xxx and xxx did and people came back and said " Great! brilliant! but we don't need it….People said "At the moment it is a nice to have and I'm not willing to pay £30-£40k for a nice to have at the moment. " .....You've got the xxxx[big pharma] lab in Belgium and it is wall to wall xxxx systems you know. If he changed over completely to xxxx[firm B's product], how much would they have to spend? That's OK, you learn from that. We were lucky that we had the CRO business to buffer that failure and it looks as if we have something quite interesting developing."* BR42009/18

This example also highlights the role of building relationships with potential customers to enable the assimilation of knowledge.

- *Assimilating knowledge for route to market/distributors*

This study finds that with options of how to commercialise innovations, the assimilation of market knowledge enables HTNVs to make decisions about the most appropriate route to market. For example, assimilation of market knowledge about market dynamics and current distribution channels enabled case G to make decisions about the type of marketing company required to promote their product.

> *"The strategy is to work through an existing commercial player, hopefully a big one that has the resources and ability to educate and influence the market and those big players are global"* GR22009/15

> *"Do you go for the top guys or do you go for someone smaller who will do an exclusive deal with but you won't get penetration of the market so quickly. I think we are conscious of all the factors and we will assess it on an on-going basis."*GR22009/26

This study finds that there is significant overlap between route-to-market and internationalisation decisions which is covered in the next section.

c) Assimilation of knowledge in relation to internationalisation

HTNVs with limited resources must make choices about the most effective way of making a return on their investment. The evidence from this study suggests that the evaluation of geographical market entry choices includes assimilating market and regulatory knowledge for that market to assess the likelihood of success. For example, case I demonstrates the firm's assimilation of regulatory knowledge to assess the impact that regulatory authorities on profit margins if regulatory approval is delayed. Acting on this knowledge, they chose to launch their product in the US first and organised their clinical trial and FDA submission in a way to maximise the speed through the necessary regulatory process.

> *"We went to the US for two reasons, one we thought conducting the study in the US would be a good thing because we had planned to approve it there and the authorities always like to see that and also the speed of getting approval... It is not just about clearing the regulatory hurdles, it is about getting there quickly"* IR12010/11

> *"in the US, you supply the product to the supply chain and you just make sure that when the chemist reaches for a xxx, that they reach for yours rather than the competitors one"* IR12010/17

The firm's ability to understand the implications of regulatory knowledge on the speed of approval and ultimately the return on investment and the profitability of the firm, comes from the significant prior experience of the founders in other firms in the pharmaceutical industry.

Case I demonstrates that internationalisation decisions are closely linked with decisions about the most appropriate route to market. The assimilation of market knowledge and regulatory knowledge enabled a decision to be made to enter the US market via a marketing partner, not because the firm didn't have the capabilities to launch it themselves, but because they are cash constrained and cannot cover the cost of a likely lawsuit from competitors. This case also highlights the challenges faced by cash-strapped HTNVs when launching a product in an international market.

> *"Because we are on a different continent…. these guys are doing this all the time and importantly one of the things that can happen in the US is that you're sued by the originator company. And they can sue us if we infringe their patent but we don't…. The reason that people get sued is to delay you coming to the market because you can't launch until that is resolved so the process can be 14 months or it can be 30 months…we don't know. But from our perspective, what we wanted was a big brother who could help us through the process and these guys are really good at litigation. That was important for us, because we could technically have done it ourselves, it would have been more profitable ultimately but we might have had to spend $5m . It is difficult to raise money for a law suit"* IR12010/16

d) Assimilation of knowledge in relation to assessing the impact of regulatory authorities on the firm

This study finds that as the life science industry is heavily regulated, all cases have to be able to understand the impact of regulatory authorities on the firm. Although the relevant regulators publish their guidelines on the internet and they are freely available, understanding the impact that particular regulations have on HTNVs and their customers is not straightforward. The ability to assimilate and interpret the guidelines appropriately is challenging and for companies able to do this effectively it can be a source of competitive advantage.

For example, case D demonstrates clearly how assimilation of regulatory knowledge allows the firm to understand how it impacts on customers, generating market knowledge for the firm and allows the firm to position their service offering accordingly.

> *"We actually had in our original emails, we used to say we were based in xxx [Scotland]. I've taken that out. It has put off at least one client because they were concerned that we were sourcing xxx in the UK and the regulations were different, although they are actually tighter in the UK. Now, in our general introductions, we always stress that we will source in the US for US clients so there's no confusion"* DR12008/4

Similarly, assimilation of regulatory information enabled case F to understand the regulatory hurdles and how to overcome them. Case F chose specifically not to position their first product as a diagnostic due to the regulatory authorities' requirement for clinical trial data. This was not because they didn't think the trial would be successful. In the interests of making a quicker financial return, case F put the device on the market as an aid to self-diagnosis while building up a dossier of clinical data that could be used to achieve regulatory approval for the device as a diagnostic at a later date.

> *"We've chosen to, and had to position the product as an aid to xxx if we classified the device as a diagnostic device we would have massive hurdle to overcome on the regulatory side…clinical trials, proof etc., and I think we've got data that proves the product can work, but how well it works is really what the clinical trials would have to show."* FR12008/3

Once a drug is licensed and being prescribed to patients, it would be significantly detrimental to patient welfare for that drug to be temporarily unavailable due to production issues. Case A highlights how assimilation of the regulatory requirement for two independent suppliers of key manufacturing processes for human therapeutics, enabled the firms to understand the dynamics of the market and to identify opportunity gaps in the market.

> *"The FDA insists that you have two verified raw material suppliers so that your production can't go down…they have to have disaster policies. You can't have a drug on the market and people on that drug, and then suddenly say*

> *we had a few production problems, so you are not getting your drug this week. So it is all very heavily controlled from that point of view."*AR1 2009 /2/11

> *For some companies, once a firm has been approved as an FDA verified supplier of a particular component, and if the clinical trial progresses, then the commercial success follows. As long as we get it right, we are locked into this chemistry, we are locked in to this particular customer and then, when they license the people to use the chemistry there is an obvious place to go to get the xxx, so that's us, so you have a virtuous circle for a while."* AR1 2009 /2/14

For case B, assimilation of regulatory knowledge and market knowledge from customers led the firm to understand that it could develop a competitive advantage if it gained GLP accreditation from the MHRA.

> *"So it was really the market that said "for you to differentiate yourself from academics, GLP, is the thing you need."*BR22009/18

In this section, analysis of what knowledge is assimilated highlights that a combination of different interpretations of market, technical, regulatory and international knowledge enables HTNVs to find solutions to the multiple challenges faced at critical events. The importance of the relationships with customers is also highlighted as an enabler to understanding and interpreting new knowledge and its implications for the firm.

7.5.2 How is external knowledge assimilated?

The previous section has described the understanding that HTNVs in this study gained as a result of assimilation of knowledge. This section describes how the assimilation of knowledge occurs. This study finds that key individuals that acquire knowledge for the firm perform initial assimilation as part of the process of recognising the value of knowledge. Furthermore, this study provides significant evidence that experiential knowledge of individuals has a significant impact on the capability to assimilate external knowledge. The ability to interpret external knowledge and understand what it means for the firm has been shown to be directly dependent on the management's knowledge of the industry dynamics. It also highlights that the relationships that the firm has with customers and potential customers is a key factor in enabling the interpretation of the implications of the knowledge it acquires.

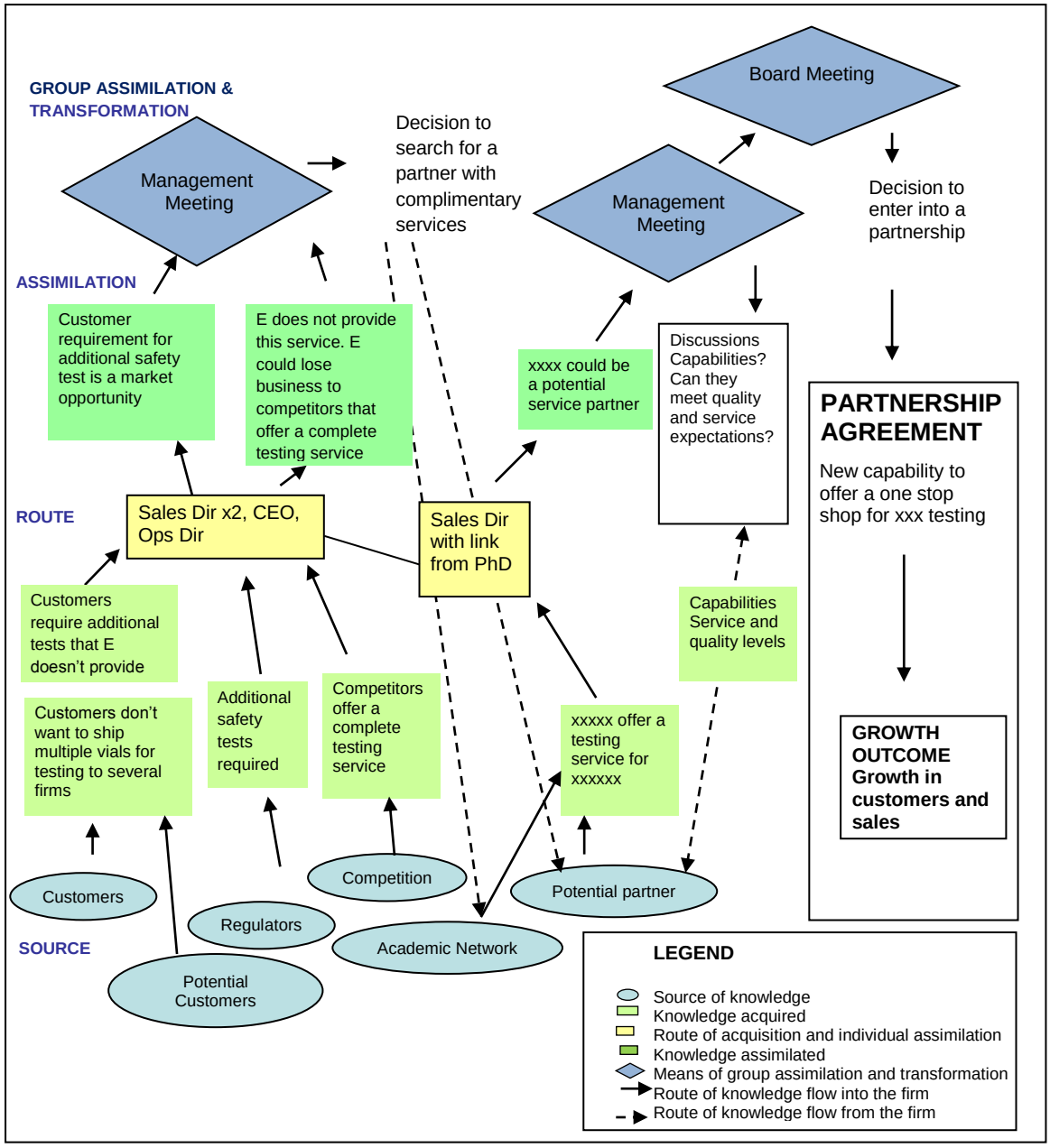
Visual maps, created during the within-case analysis, illustrate how external knowledge that is acquired by individuals is initially assimilated by them and that interpretation is communicated to others within the firm. These visual maps show external knowledge undergoing group assimilation as the firm management asks "What does this mean for our

company?" Section 7.3 highlights that a consistent message being interpreted from external environment by multiple members of the management team increases the intensity of the message. Example visual maps of the leverage of knowledge in Figures 7.4, 6.2[7] and 6.8[7] illustrate the importance of combining assimilated knowledge from different perspectives to assist with understanding of an opportunity or threat and what it means for the firm. Individual acquirers of external knowledge disseminate their interpretation of that knowledge to colleagues in relevant teams across the firm. This enables the group or team addressing a particular challenge to come to a collective assimilation, or shared understanding of what a signal from any particular element of knowledge means for the firm. This is a vital precursor to enabling decisions to be made in the transformation step.

Figure 7.4 is a visual map illustrating the leverage of knowledge through the ACAP process which led to the establishment of a strategic partnership in case E. The map illustrates external knowledge being acquired by several customer-facing sales staff within case E. Knowledge from a variety of sources from regulatory authorities, customers and potential customers add validity to the market knowledge that customers require additional services. The assimilation of the combination of knowledge regarding customer preferences and reviewing competitor service offerings leads Firm E to understand that customers require additional testing services that they do not have the capabilities to provide, and perceives a risk of losing business to competitors who can provide a holistic service. A well-established link of one of the founders provides the firm with knowledge of a potential partner that could provide these complimentary services. The firm assimilates this knowledge and understands that it could increase sales if it can offer a more holistic service by collaborating with a partner that can provide complimentary services. Further knowledge about that potential partner's capabilities, service and quality levels is then assimilated which results in case E signing a partnership agreement which facilitates the creation of a new joint capability which in turn increases sales growth. This case again highlights the important role of both experiential knowledge and relationships with customers and potential partners to interpret the meaning of external knowledge.

[7] See visual maps in Chapter 6

Figure 7.4 Leverage of knowledge for establishing a strategic partnership in Case E



Source: Visual map developed from within-case analysis of interview transcripts

Figure 6.2[8] illustrates the analysis of the leverage of knowledge through the ACAP process for new market entry in case A, highlighting that although the assimilation of external market knowledge suggested that there might be a market opportunity that could offer significant growth potential for the firm, the initial outcome of the process created further questions rather than solutions. The outcome from this assimilation process instigated a number of further iterations of knowledge acquisition and assimilation involving a number

[8] Visual maps in Chapter 6

of key roles within the firm. The complex network of relationships established to enable knowledge acquisition, also facilitated assimilation, building a complex picture of the motivations of a number of key players in the organisations they wished to do business with. The prior knowledge of case A's management team facilitated the understanding of this complex web of information.

Figure 6.8[9] illustrates the assimilation of in-depth customer specific market knowledge which enables the firm to tailor its service offering to the specific needs of that company. The assimilation of regulatory knowledge creates market knowledge which gives the firm confidence to invest the time in getting their initial offering right for the new market.

> *"The FDA regulated companies don't want too many suppliers so the smaller number of suppliers they have to vet. They have to spend quite a lot of time doing the audits and so on, so that they try to keep the number relatively small. Having got in with one product, it increases the likelihood that when they need another product of that ilk, they will come to us first and say can you do this one"* AR12008/14

This visual map illustrates how assimilating external knowledge from customers enabled case A to understand the decision makers within the firm who they needed to influence. Furthermore case A assimilates the significant time delay between initial discussion with a pharmaceutical or biotech company to include a product in the early research phase manufacture to supplying a manufacturer for clinical trial quantities.

7.5.3 Intra-organisational communication as an enabler of assimilation

This study has already highlighted that in order for external knowledge to be assimilated and exploited successfully, it must be communicated to the parts of the business that requires it. This is consistent with Cohen and Levinthal (1990) who highlighted communication as a key factor in ACAP. This study investigates the routine processes in place within HTNVs for dissemination of acquired knowledge in order for it to be assimilated by the part of the business that needs it. Dissemination of knowledge throughout the firm and assimilation by appropriate teams of empowered individuals can be seen to be a key precursor to transformation of that knowledge. Although Zahra and George's (2002b) position social integration mechanisms as enabling the transition between potential and realised ACAP, the findings of this study would suggest that it impacts on the transition between individual- and firm-level assimilation of knowledge.

[9] See visual maps in Chapter 6

As previously highlighted in sections 7.3 and 7.4, individuals who act as gatekeepers of knowledge within HTNVs play a very important role in the flow of knowledge into the firm, having firstly recognised the value of knowledge and acquired it. They must understand its significance even if they don't know its full potential, to alert colleagues that they should be aware of something. Previous experience can be seen to play a key role in understanding the potential value of knowledge in order to prioritise translating that value to an internal audience within the firm. As external knowledge may not be understood by all within the firm, it may need to be enhanced or elaborated by the understanding of the gatekeeper, to provide more user friendly knowledge to colleagues within the firm. This research also suggests the value of multiple perspectives on a particular issue being shared within the firm, as one individual may not have the ACAP to understand the relevance of particular environmental changes.

Table 7.12 summarises the social integration mechanisms for knowledge found in the cases within this study. The HTNVs in this sample are predominantly very small firms with less than 50 employees. The findings show that when firms are very small (cases D, G and I),

Table 7.12 Examples of knowledge dissemination within case firms

Case	Size banding (FTEs)	Social integration mechanisms
A	21-30	NPD meetings/ Management meetings/intranet
B	16-20	Management meetings
D	<5	Face-to-face discussions/weekly meetings/ information management system
E	21-30	Operations meetings/ Management meetings
F	6-10	Management meetings
G	<5	Face-to-face discussions
I	<5	Face-to-face discussions
HTNV size bandings: <5, 6-10, 11-15, 16 – 20, 21-30, 31 – 40, 41-50		

Source: Developed from cross-case analysis of interview transcripts

there is little requirement for formal mechanisms of knowledge dissemination, as the as the management team are in regular contact and can easily have regular face-to-face discussions. Small HTNVs benefit from their small workforce in the way they can communicate easily to all staff, as described by respondents from firms B and D:

> *"Being 16-strong, we still all fit round this table, so we have weekly meetings which are really good because the flow between operations, sales finance, all of the groups works really well, because in other companies, particularly larger companies, sales people don't like operations, because they think they never deliver and operations say sales people just swan around all over the world. I think because we are still small enough… I guess the challenge for us as we grow to keep this mentality and this great communications the bigger we get. We also have an annual company meeting where we talk more broadly on business plans, deliverables, everyone's targets, and where they were generated from. What is also amazing about the company, even at technician level, they understand that if they complete a project, how that effects revenue for that month, whether we are on target, on profitability so everyone understands that, so we need to keep that even as we grow."* BR22009/27

> *"We have weekly meetings formal meetings where we run through everything that we have on the books so to speak and what needs to be prioritise and usually it is a joint decision. It doesn't have to be… If someone isn't there and the decision has to be made…"* DR12008/23

A respondent from Firm A discussed how when the firm implemented an expansion of their facilities it communicated the process with all staff by creating a resource in the meeting room that all staff could share.

> *"One of the things we did do that was a very useful process, and it was probably xxx that initiated it, was just having a wall in the meeting room downstairs, starting at time zero here, to end of project here. And basically having sort of just sticky bits of paper you know and just mapped out the key things that had to be done and who needed to do them and when they needed to be done. And basically anybody in the company could come in and look at that, make a suggestion on it, you know. At least they could see it and then they knew who to go and speak to you know either myself or xxx in the most part, as we were the ones dealing with the contractors from the early planning stages of the work through to the actually coming on site and doing the build"* AR32009/2

Case E also highlights the impact of a corporate culture where the effective acquisition and dissemination of knowledge is actively encouraged:

> *"We have operation meetings where these things can be brought up, but because there isn't a lot of us, we tend to just do it in the office. Generally, there is a meeting where people can come and say anything and the culture that we have here is that if people see anything, they can say anything to improve. We have a completely open culture. And all these people here were selected because of their ability to be that sort of person."* ER12009/34

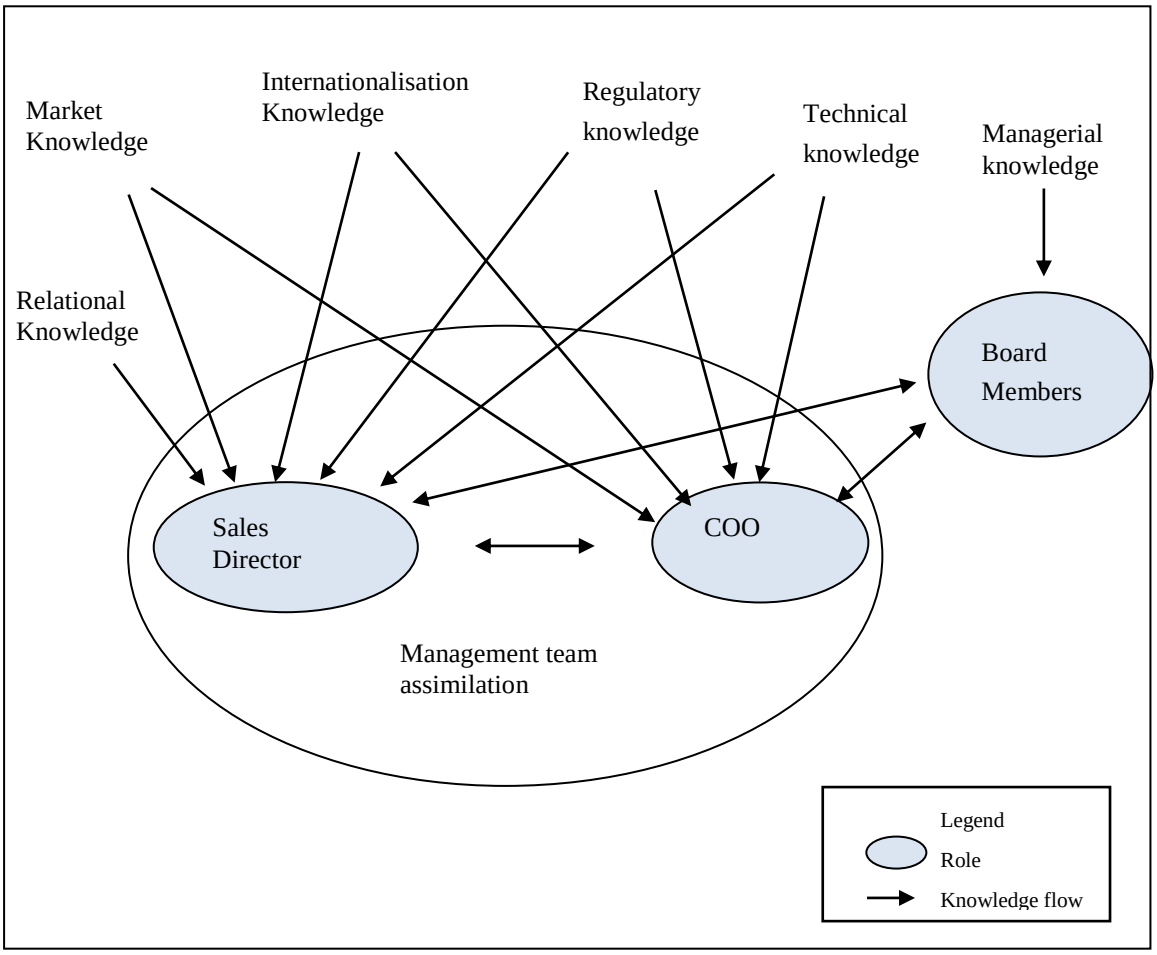
Case B highlights how increased human capital over time enhances effective knowledge dissemination and assimilation between members of the management team with different knowledge and experience, which in turn benefits decision making ability of HTNVs. One of the respondents from Case B describes the challenges of taking growth plans to the board members and investors, when the firm was young with very little human capital responsible for acquisition and assimilation of lots of different external knowledge in order to develop the strategy:

> *"in the early days when it was just xxx and I doing the internal discussion and taking stuff to the board everything kind of fell on our shoulders and that was high pressure in the early days and although there is the offers of support, no one really knew the xxx market. The Board is experienced in things that they've done. Running businesses and selling businesses but no one really knew about the xxx market so it felt like a hell of a lot of pressure. Now there are 6 people with very different backgrounds with good understanding for the pre-clinical lab CRO industry so it is a nice group to bounce ideas off. That's a much better position to be in."* BR22009/22

Figure 7.5 illustrates the flow of knowledge into the firm through two key individuals and the limited assimilation capacity of the early management team. With additional human capital over time, and the appropriate mix of experience in the management team, the firm assimilates and disseminates a greater variety of knowledge more effectively and the management team has more confidence in its decision making capabilities (see Figure 7.6).

> *"it means we have a 6 man strong internal management team, compared with what we had in 2006, that's fabulous, lots of people to bounce ideas off, so the senior management meetings are really good. So really all of our initial strategy and way forward is profitable, everything is discussed in these meetings and then xxx[CEO] and xxx who is our FD would take that to the Board."* BR22009/21

Figure 7.5 Knowledge flows 2 years after foundation (Case B)



Source: Diagram developed from within-case analysis

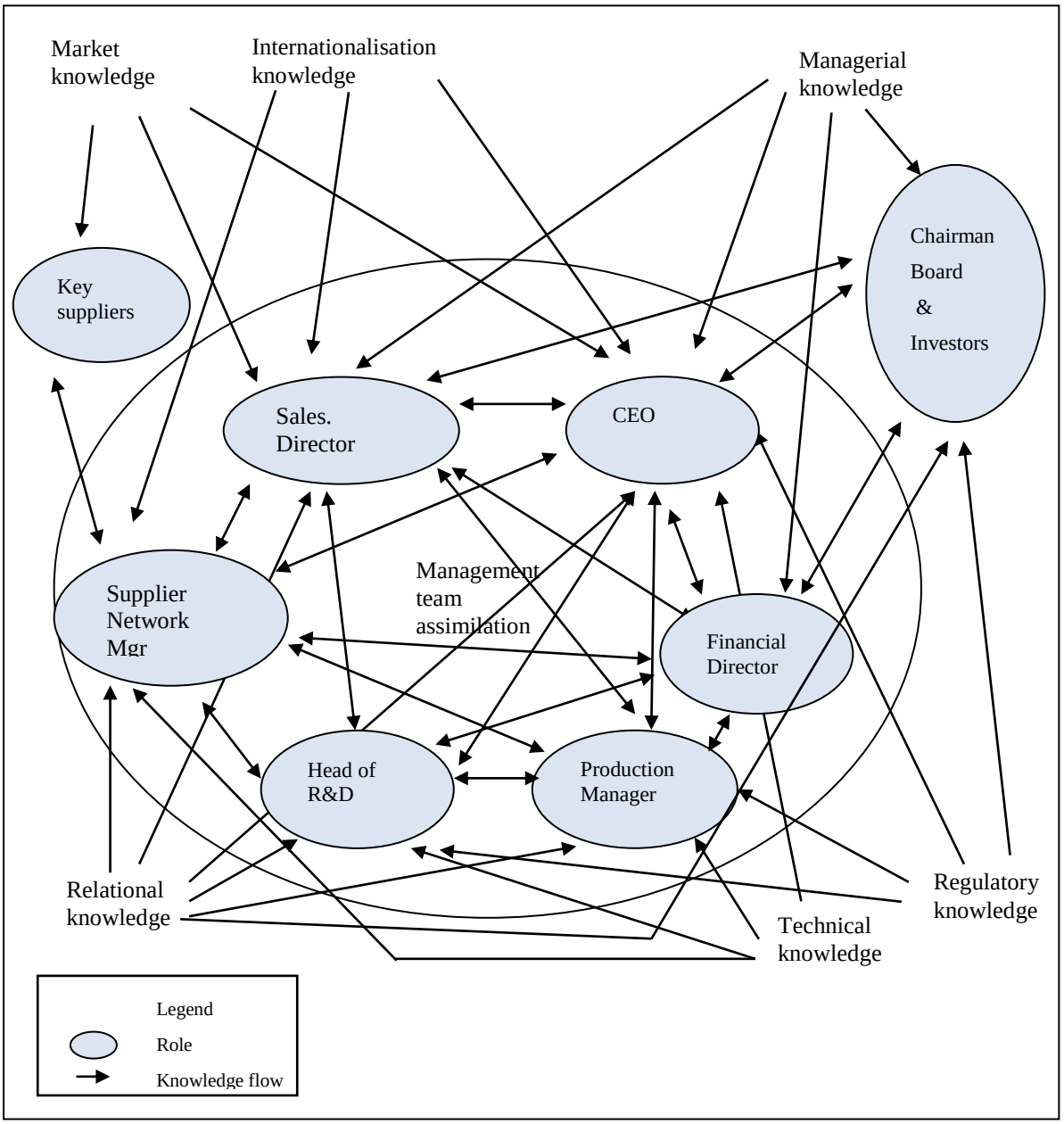
Another respondent from Case B describes the benefits of effective dissemination of knowledge in the firm:

> *"From a marketing opportunity point of view the knowledge has to come from xxx and sales what's out in the market place, but the internal knowledge has to flow from xxx[Ops] and xxx[CEO]. The Quintiles and the Charles Rivers of this world, there's not that movement in knowledge between the two sides."* BR4 2009/11

This study also highlights that as HTNVs grow, there are new challenges to maintain effective communication as number of employees increase, more professional management reduces the cross-functional working common in very young HTNVs, and often employees work in multiple locations. As case B, has recently recruited more staff, a respondent highlights the challenge of maintaining effective communication between the different parts of the business:

> *"there wasn't really a distinction between operations and sales until now and even now they are very closely aligned, but now we are at a size where sales have their own division. There are 4 people in that now that they have to communicate with the ops division."*BR12009/2/5

Figure 7.6 Knowledge flows 6 years after foundation (Case B)



Source: Diagram developed from within-case analysis

Therefore, it is clear from this study that a number of other factors also impact on the social integration mechanisms in the firm, such as the breadth and depth of experience within the firm, and the organisational structure and culture. These are discussed in more detail in section 7.8.

7.5.4 Social capital as an enabler of assimilation

Social capital has already been identified by this study as a key resource for HTNVs for accessing external knowledge. In addition, it can also be seen to have an impact on the firm's ability to assimilate that knowledge. This is for a number of reasons:

Firstly, a level of confidence and trust is developed between the firm and the link by maintaining the relationship makes the knowledge from these sources more credible and is more likely to be assimilated. This study proposes that this can have a positive impact as it enhances the speed that the firm assimilates this knowledge. There is also a potential negative impact as the firm may place unfounded importance on external knowledge acquired from a trusted source.

Secondly, due to the trust and connections between the two parties, it is likely that relationships that firms form with key players in the market can assist in the interpretation of external knowledge, which makes it significantly more valuable knowledge if the firm can readily understand the impact it will have. These findings reinforce the views of Nahapiet and Ghoshal (1998) that intellectual capital is a social artefact and that meaning is derived from knowledge in a social context, which is sustained by on-going relationships. For example, Firm E acquires external regulatory knowledge from strong relationships with customers, as described by a respondent from case E:

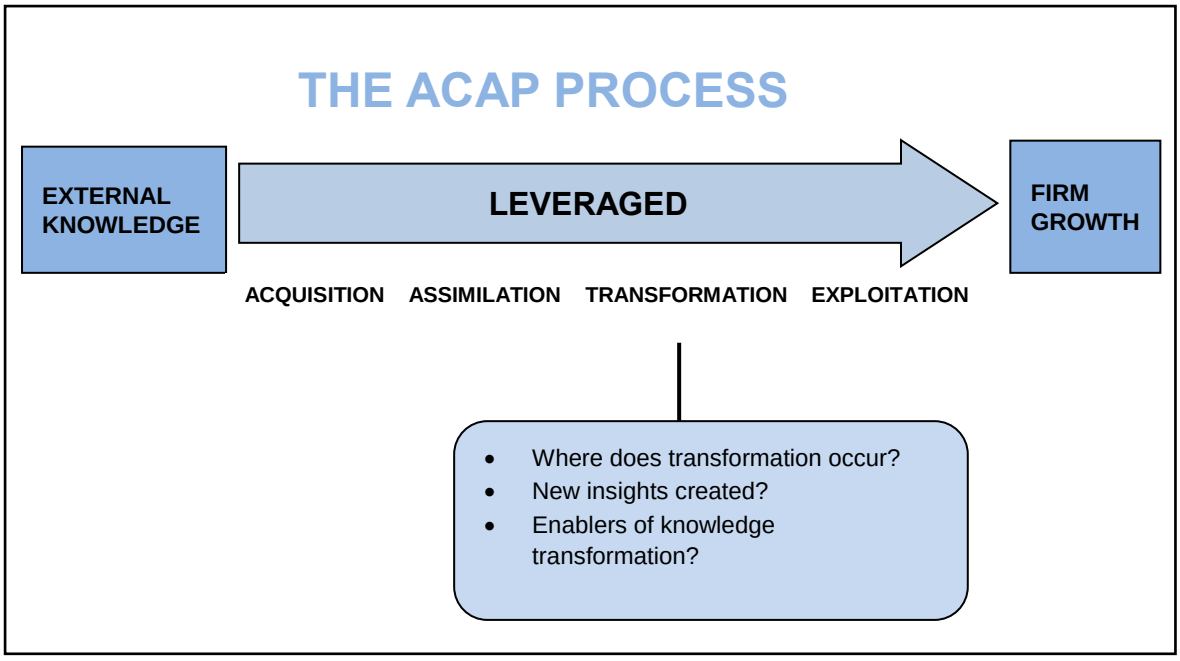
> *"Customers are a continuous feed of the knowledge. They are the people who are constantly communicating with the regulatory authorities to get their drug on the market. So at every meeting they [the regulatory authorities] say you should do X Y and Z and they [customers] come to us and we do it. So they feed us a lot."* ER1 2009/29

Lastly, social capital within the firm also plays a part in effective communication between different parts of the business and this has been shown to be of particular importance as firms grow.

7.6 Transformation of external knowledge by HTNVs

Zahra and George (2002b) introduced the concept of transformation defining it as reframing external knowledge to build new cognitive structures. The previous section highlighted that prior to transformation, external knowledge is assimilated and acquired by key gatekeepers, who disseminate that knowledge to relevant teams who develop a collective understanding of what that knowledge means for the firm. This section outlines how the HTNVs in this sample derive new insights by combining new elements of assimilated knowledge along with the existing stock of internal accumulated knowledge to enable key decisions to be made. Evidence of the transformative capability within the firm in this study are decisions made following assimilation of external knowledge, which have led to the development of capabilities that address the growth challenges faced by firms at critical events within the firm that contribute to the firm's growth and development.

Figure 7.7 ACAP as a research lens – the transformation dimension



Source: Developed by the researcher (adapted from Zahra & George 2002b:192)

7.6.1 Where does transformation of knowledge occur?

Transformation occurs among a team with management responsibility, and the level of seniority of decision-making depends on the significance of the decision being considered and the investment required to implement it.

Figure 6.6[10] illustrates the transformation of market and technical knowledge for routine new product development in case A taking place at new product development meetings. This visual map shows knowledge from different perspectives is assimilated individually by different members of staff, each interpreting what this external knowledge means for their part of the business. This external knowledge, which is perceived to be of value, now enriched with the gatekeeper's interpretation is transformed at New Product Development meetings. The combining of knowledge from different perspectives enables further understanding of new product opportunities. This team in Case A is empowered to make new product development decisions and often decides to develop and manufacture a test batch of product and use it to test market demand. These findings highlight the impact of culture of empowering staff on the transformation of knowledge, enabling the firm to leverage value from external knowledge. In contrast, the transformation step where knowledge is combined to enable a decisions to be made about building capability which requires significant level of investment (e.g. Figure 6.3[10]), can be seen to take place in the management team with a higher level of decision making ability.

7.6.2 Transformation of knowledge creates new insights which enable decision making

Transformation of one type of knowledge into another (i.e. knowledge creation) is evident throughout the sample in this study, where new insights gained from the combination of different types of knowledge act as a 'tipping point' which precipitate critical events for the firm. Examples below from the within-case analysis demonstrate the transformation of knowledge which enables the resolution of challenges the firm faces at critical events. In a number of cases, very little new knowledge was required to enable decisions to be made quickly. For example, the assimilation of regulatory knowledge, combined with market

[10] See Visual maps 6.3 and 6.6 in Chapter 6

knowledge enables firms to create internationalisation knowledge. Cases B and D have assimilated knowledge relating to regulatory issues on both the demand and the supply side, and as a result of transforming that knowledge, both firms source their high consumables from outwith the UK due to the bureaucracy which slows down the supply in the UK. Similarly, a respondent from Case I describes the internal process of combining different types of knowledge to enable new insights about prioritising new product development candidates:

> *"We figured that it was a good way to improve medicines and it hadn't been done a lot and you could protect it. We came at it from three angles: The angle of whether it was technically possible, whether it would produce a differentiated product and whether it would be prescribable. And the last thing was what the market potential would be against it and there is no point in doing it if there are only 6 patients in the world with that condition. It has to make sense."* IR12010/28

Case G describes how the combination of assimilated market knowledge that suggested that the market had opened up, along with internal managerial knowledge that the service business was not generating the income that had been anticipated, enabled the board to decide to change the strategic direction of the firm.

> *"The service business was going to generate enough money to allow the development of the xxx to proceed, while there was a cash flow being generated but it didn't prove to be enough of a cash flow to make that viable."* GR12009/25

This study also finds evidence that suggests that as firms acquire and assimilate new external knowledge from customers, that knowledge is transformed and new insights are drawn about the internal processes within the firm. For example, case A describes the challenge of cementing relationships with new customers in new markets. Once new customers are on board and the firm acquires and assimilates more knowledge from these new customers about their internal processes, that knowledge in combination with the firm's current knowledge about its production processes creates new insights regarding potential adjustments to their internal processes to meet the specific requirements of this specific group of valued customers.

> *"We are right in the middle of that at the moment with the first of these customers and it is proving to be even more complicated that we had anticipated…It had to be a step change and it certainly has been and it has also been somewhat of a culture shock."* AR1 2009/2/8-9

Case B also described the process of transforming market knowledge from customers and potential customers and changing its service focus as a result.

> *"I think we have learned a lot in every project about what is important to the client, the direction that they are going in and as I said, we thought we would start off in efficacy and our clients led us down the safety route. Every client or every contract we learn from."* BR22009/25

7.6.3 Enablers of transformation

It is evident from this study that a key enabler of the transformation of external knowledge is prior knowledge and experience of decision makers which enables new insights to be drawn from the combination of new assimilated knowledge and existing stocks of knowledge within the firm.

Another key enabler of the transformation of knowledge is a combination of culture and governance within the firm which empower staff to draw new insights from the combination of knowledge and make decisions based upon these insights.

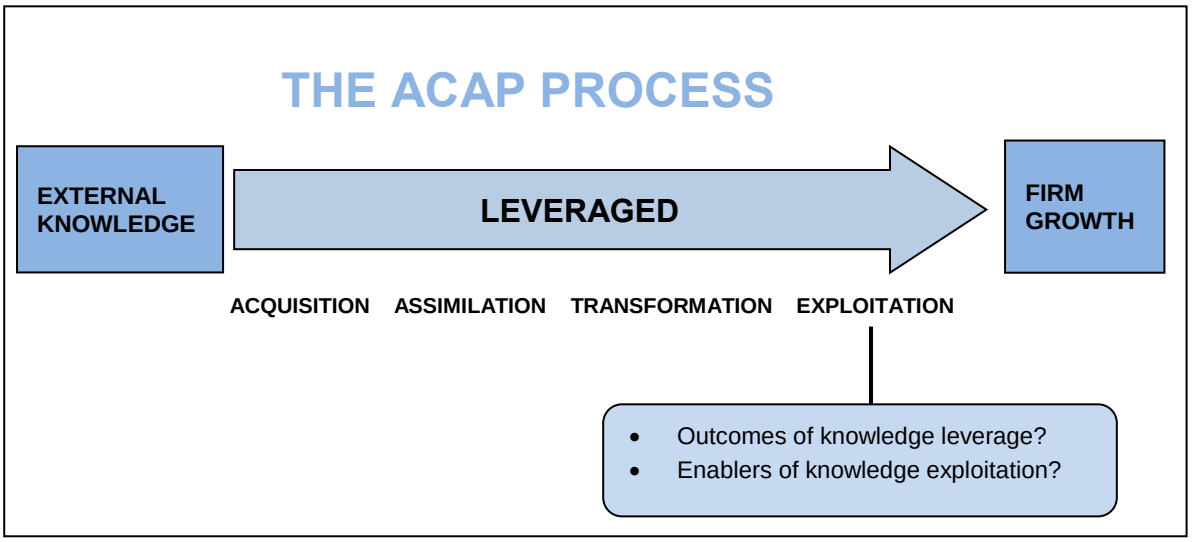
Investment of resources is a key enabler of the leverage of knowledge. The ability to raise finance is particularly important to the transformation stage to enable the building of capabilities to address the challenges the firm faces in responding to market opportunities. Although the firm may assimilate knowledge which it interprets as a market opportunity, it may not have the resources to respond to that opportunity without additional investment. This study finds evidence of product development and market development ideas being parked while the firm takes their first product to market. In two cases (A & E), government grants enabled firms to reduce the investment risk. Furthermore management capacity to allocate time to evaluating new opportunities by combining new knowledge with existing knowledge stocks is a factor in the leverage of external knowledge. The experience and market awareness of the individuals involved in transformation also plays a part in enabling the understanding the market demand and dynamics when generating new insights from assimilated knowledge.

The enablers of the leverage of knowledge are summarised in section 7.8

7.7 Exploitation of external knowledge by HTNVs

Exploitation of external knowledge is evident in all cases within this study, although there is seldom an immediate growth outcome as a result of a single iteration of the ACAP process. However, an outcome of the leverage of knowledge through the ACAP process is often an understanding that further external knowledge is required to enable a decision to be made, or that a stock of knowledge must be developed to capitalise on an opportunity. Therefore, a key finding from this study is that the leverage of knowledge is an iterative and cumulative process.

Figure 7.8 ACAP as a research lens - the exploitation dimension



Source: Developed by the researcher (adapted from Zahra & George 2002b:192)

7.7.1 Outcomes of the exploitation of knowledge

This study finds that outcomes from the exploitation of external knowledge by HTNVs are as follows: a) resolving growth challenges and growth of the firm, b) new organisational forms and c) the building of stocks of knowledge

- *Resolving growth challenges*

This study finds that the HTNVs in this study have successfully leveraged external knowledge to address the multiple challenges associated with critical events that were

identified in table 7.1. Due to the significant time lag in the life science industry, the expected increases in sales revenue and growth of the firm cannot be seen during the timescale of this study. Firms can however be seen to be making progress towards their objectives.

For example, case B provides an example of an outcome of the leverage of external knowledge which one of the key challenges associated with the critical event of focussing on its service business, which has enabled the firm to improve efficiencies within the firm and reduce the time taken to deliver projects for customers. The acquisition and assimilation of knowledge acquired from building links with suppliers, has enabled a more reliable supply of specialist high value consumables. This in turn has generated greater sales volume, lower attrition rates and higher profitability.

> *"So xxx sourcing is a major challenge for the business and I would say in the early days I would say it really held us back, because we couldn't deliver contracts for xxx. … In 2005 we were 6-9 months to complete a project and in 2008/2009, we deliver in 12 weeks and it is the same type of project."* BR22009/13

This study also finds that outcomes of the leverage of knowledge can be innovation in management processes which impact on all activities within the firm. Case A provides an example of innovation in management of knowledge processes triggered by the requirement to communicate effectively with international customers:

> *"Because now we are in there with these guys sitting round, metaphorically speaking, sitting round the table because they are xxx and we are here. Every Friday, we have an hour long telecom with these guys and there are 5 of them at their end (there are 3 in one location and 2 in another) and there are 5 of us here. We sit down and have an hour long weekly meeting to review progress on xxx for that company. It has just taken us into a completely different way of working and it has been quite a culture shock for us."* AR1 2009/2/9

- *New organisational forms*

This study finds that many relationships are formalised in order that exploitation of the knowledge can occur. The reason for this formalization of relationships may be explained by the transaction cost argument (e.g.: Sampson, 2004:421) that suggests that firms want to protect the knowledge assets they have built up, creating "a structure that both supports the efficient transfer of knowledge based assets and also minimises unintended leakage of such assets to potential competitors". The strengthening of the relationship leads to more formal collaboration, licensing, sales orders etc. Case A, for example has successfully cemented the relationships with potential customers and is now a key supplier of components in a niche global value chain. The new organisational forms developed that have resulted from the social capital of the firm are summarised in table 7.13.

Table 7.13 The transformation of social capital into new organisational forms

Social capital	**D/I**	**Pre/post**	**Knowledge**	**E/T**	**New organisational form**
Academic Links	D&I	Pre & Post	TK, RelK	E&T	Customers (A)Satellite research facilities (B), Licences to IP(A), access to research equipment(A), landlord(B), supplier(D) Product testing site(B), clinical trials site(G), Scientific advisory board (G)
Existing business links	D&I	Pre & post	MK, TK, RK, IK, RelK	T	Chairman(A), Customers(A,E,D)
New business links	D&I	Post	MK, TK, RK, IK, RelK	T	Customers(A,B,E), Product testing site(B), suppliers, Distributors(I)
Supplier links	D&I	Post	MK, RK, TK, IK, RelK	T	Distribution agreement(D)
Gatekeeper links	D&I	Post	MK, TK, RK, IK, RelK	T	Customers (D)
Personal links	D&I	Pre	MK, CK, TK, RelK	T	Business partners(D), collaborations(D,E), agent(F), customers(E)
Special interest groups	D&I	Pre & Post	MK, TK, RK, RelK	E&T	Customers(A,D,E), new staff(E)
Local networks	D	Post	TK, CK, RelK	E&T	Customers (D), supplier(G), Investors (E,I)
Board member links	D&I	Post	MK, TK, RegK, IK, RelK	T	New board members(I,B), advisers (F), Investors(E), new staff(B)
Types of knowledge:T=Tacit and E=explicit knowledge categorised as per Nonaka (1994) Types of knowledge: TK=technical knowledge, MK=market knowledge, CK=commercial knowledge, RK=regulatory knowledge, IK= Internationalisation knowledge, Geographical location of links: D=Domestic, I=International; Timing of making the link: Pre=Pre-foundation, Post=post-foundation					

Source: Developed from cross-case analysis

- *Building stocks of knowledge*

Evidence from this study suggests that the outcome of the ACAP process is often a new knowledge asset that adds value to the firm and can be utilised in the future. In knowledge-intensive industries, HTNVs create value by developing new stocks of knowledge from the combination of existing knowledge stocks and various types of external knowledge. Indeed, the firm may also realise that they need to develop knowledge stocks internally in order to be able to exploit the opportunity. All firms that have to obtain regulatory approval for their product must build up dossiers of appropriate clinical evidence in order to obtain this approval for their product in the given geographical market. Creating this stock of knowledge takes time and often significant financial investment. Building stocks of knowledge in knowledge intensive HTNVs adds value to the firm. Firms can be seen to be worth more as they reach critical milestone in the clinical development of products.

- *Knowledge management as an enabler of exploitation*

Due to the significant value of the knowledge stock they are accumulating, knowledge management within the firm is a very important issue, as described by a respondent from case I:

> *"we've got quite a reasonable IT set up for all the company information, we have a data room set up so all the important information goes in there, and they are also kept by our solicitors as well. We try not to keep anything here that is particularly important for reasons of security. That's how we manage information."* IR12010/26

Even when firms do not require clinical data by regulators, they still need to build up a stock of evidence that backs up their marketing claims in order to assist with the marketing of the product, as highlighted by case G:

> *"…what we are also doing is building up in a controlled way, our clinical data to support our marketing claims"* GR22009/5

Assimilation of market knowledge from customers led case B to decide that it would require validated assays to fully capitalise on the service business. However, it this knowledge resource which is now used as a marketing tool, took significant time and was costly to develop.

> *"That clearly from the market, the only way we were going to sell this if the assays were validated. We were kind of being naive going to the market without a validated assay, so really [year x] was kind of trying to keep our early clients happy while trying to build up our validation data. Which is why this assay development group that we now have 2-3 years later is going to make things so much easier."* BR22009/16

A respondent from case G describes spending time building knowledge stocks prior to looking for investment funding, in order to create value:

> *"We were working on the actual methodologies, a couple of years before we thought we were actually in a position to build it into a company."* GR12009/19

This study finds that as new knowledge is created, in order for that knowledge to be exploited in the future, it has to be managed effectively. For example, in order to effectively manage knowledge across all relevant parts of the business, case A has introduced project management software that acts as an intranet and assists with communication across the firm, as respondent from case A describes below.

> *"…we now use a piece of project management software called xxx…you can actually see how often people are reading it so you know how many people are reading it and when. So on average I think people read it every two or three days, something like that. So you have the ability to make a comments, so even if it isn't your project, you still have the ability to say "I think you should try this". So that is actually working very well and these meetings 6 weekly meetings now deal with problems…. So it is just a slight change, nothing different in the fundamental process, just the way we manage it. It is more interactive… The only change is in the way we manage the day-to-day and trying to encourage much more involvement."* AR1 2009/2/3

Managing knowledge is also important to firm D; even though it is small and management are in daily contact, standard operating systems have been put in place to manage orders.

> *"we've got structure in place so we save information on an enquiry, where we are going to source things form so that someone else can just dip into that….And take over if need be…..we're putting together a database of sources*

whether we've used them before, including clinicians and academics .I guess that is really important we have a joint spread sheet for tracking. A deal tracker - a pipeline and one for live projects as well." DR12008/28

This study again illustrates that the time taken to build knowledge assets in the life science industry means that the investors may not obtain a return on their investment for many years, even though the value of the firm has increased.

- *Types of knowledge stocks created by HTNVs*

As HTNVs, the cases in this study are by their nature in the business of creating intellectual assets that they can capitalise on. While investors have traditionally valued the stocks of knowledge within HTNVs in the life science industry using the firm's product development pipeline as a measure of technical competence (DeCarolis & Deeds, 1999), the findings of this study suggest that firms need a combination of knowledge to be able to capitalise on a particular intellectual asset, which is consistent with Dierickx and Cool's (1989:1508) view of interconnectedness of assets stocks. For example, cases with consumer products can only capitalise on their intellectual assets once they have understood the route to market and has established relationships with a distribution network established. Although the concept of ACAP was developed in the context of the absorption of technological knowledge (Cohen & Levinthal, 1990), this study emphasises the applicability of the ACAP process for all types of knowledge, from innovations in management techniques, quality systems, manufacturing know-how.

This study finds that the firm builds stocks of knowledge in 6 key areas: 1) Technical knowledge, 2) Market knowledge, 3) Regulatory knowledge, 4) Managerial knowledge, 5) Internationalisation knowledge and 6) Relational knowledge (As described in section 7.4.2). While some knowledge types are specific knowledge assets such as technical knowledge, and market knowledge but others are more functional capabilities such as managerial knowledge and relational knowledge. Exploration of new knowledge is viewed by many as being dependent on the accumulated stocks of knowledge in the firm (Katila & Ahuja, 2002; Penrose, 1959), therefore the ACAP process is dependent of the accumulated knowledge stocks within the firm. It is suggested by Lin and Wu (2010) that knowledge depth, the accumulated level of a firm's knowledge stocks, is a significant restraining variable that moderates the relationship between knowledge sourcing strategies and performance. However, the findings of this study would suggest that knowledge breadth and the heterogeneity of knowledge bases and capabilities is the main determinant

of competitive advantage, consistent with the knowledge based view of the firm. Types of knowledge are seen to be interlinked, for example this study found that assimilating market knowledge from customers, also increased the firm's stocks of technical and regulatory knowledge as part of the ACAP process. The model of the ACAP process would suggest that in addition to the depth and breadth of knowledge the firm has built, the firm's ability to capitalise/exploit its knowledge stocks is of major influence on performance and growth.

Technical knowledge

Life sciences is one of the most knowledge-intensive industries in today's economy, and therefore the firms in this study have a significant stock of technical knowledge within the firm. However they all have additional requirements which they access by building relationships with appropriate source of the knowledge they require. These findings concur with DeCarolis and Deeds (1999) who suggest that competitive advantage and performance in the life science industry is dependent on the firm's stock of knowledge and their access to flows of knowledge. Firms need stocks of knowledge that are similar to the knowledge they wish to acquire in order that they can assimilate it.

Market knowledge

This study has shown that a significant proportion of the external knowledge assimilated by HTNVs is market knowledge, as the firm builds a picture of the potential markets to exploit their innovations. As the life science industry is fast-moving, HTNVs need to have an accurate understanding of their market environment and their position within the market

For example, this study has highlighted that discussion with customers provide the firm with market knowledge about their requirements, but also provide information about the market dynamics and the regulatory environment. This knowledge, in addition to being assimilated to evaluate a particular market opportunity or to create specific knowledge assets adds to the knowledge stocks within the firm, which in turn enables the firm to assimilate further external market knowledge. This finding echoes the work of Johnson et al. (2004) who, although not referring to ACAP, argue that in turbulent environments, the need for and value of a market knowledge store increases. They suggest that by developing knowledge bases about the trend and changes in the environment, firms are in a better

position to manage relationships. This suggests that by building links with customers, HTNVs build their stocks of knowledge which in turn build their ACAP.

Regulatory knowledge

In a highly regulated industry, regulatory knowledge is a key element of the firm's knowledge stock. This study finds that regulatory knowledge is held in two subsets: Firstly, there are the regulatory guidelines that the firm must comply with in order to be accredited or to have products approved for use. Secondly and of much more importance as a source of competitive advantage is an understanding of what the guidelines mean for customers and how the firm can develop products and services to meet their needs. Once the firm has assimilated this knowledge and combined it with existing knowledge it becomes part of the firm's stock of market knowledge.

Managerial knowledge

Managerial knowledge is important for the firm's ability to conducts its activities in a profitable manner. Managerial knowledge is held within the individuals in the managerial team, and is supplemented by the board members. A key element of the firm's stock of managerial knowledge which impacts on the firm's ACAP is what the firm has learned from its mistakes (Nonaka, 1994; Van den Bosch et al., 1999), although this tacit knowledge is seldom codified and held by individual. In this area in particular, this study finds that serial entrepreneurs and board member that may also be serial entrepreneurs themselves with many years of experience (good and bad), can make a significant contribution to the ability to assimilate knowledge and transform it in a way which avoids similar pitfalls that they have already experienced. This would suggest that harnessing the experience of board members can significantly enhance the ACAP of the firm.

International knowledge

Even though firms in this study did not think of their market activity as internationalisation, a significant majority of their activity is in overseas markets. Firms have built and hold stocks of knowledge about the preferences of customers in particular geographical markets and the regulatory knowledge relating to operating in these geographies.

Relational knowledge

This study finds that by interacting with customers and suppliers, the firm builds stock of knowledge about how to work effectively with a partner. By building these stocks of knowledge, the firm enhances the trust, commitment and stability of the relationship (Johnson et al., 2004), but it is less applicable to other relationships. HTNVs in this study have described how they build a picture of how a particular customer or partner likes to do business, which may only be relevant to that customer/partner. This is consistent with the view of Dyer and Singh (1998) who argue that firms develop partner specific ACAP, based on developing in in-depth understanding of how that organisation operates. However, these findings suggest that in understanding and meeting the requirements of one customer, the firm builds its ability to build similar relationships with other customers, and therefore this stock of functional knowledge enhances the firm's ACAP.

7.7.2 Enablers of knowledge exploitation

- *Collaborations with global value chain partners and power relationships*

This study highlights that HTNVs that form part of a complex global value chain firms are often dependent on down-stream partners for successful exploitation of knowledge. Downstream partners are in turn often dependent on regulatory approval in order for all the significant efforts by all parties to come to fruition. In these situations, the firms in the upstream part of the value chain are relatively powerless to influence the outcome. By partnering with firms that they believe have the capabilities to navigate the hurdles required is vital to successfully take the product to market. As small HTNVs can be relatively powerless to influence the distribution of the end product to the end user, this study lends weight to the view of the Todorova and Durisin (2007:776) model that suggests that power relationships impact on the ACAP process.

- *Knowledge management*

It is evident from this study that due to the regulation in the industry, there is a tradition of good knowledge management and documentation in both research and development and in the operational routines for service provision. However, it is important to manage all the firm's knowledge stocks in order that accumulated knowledeg can be exploited efficiently.

- *Market awareness*

This study demonstrates the importance of market awareness, understanding market dynamics and choosing marketing/distribution partners carefully. There is evidence that the leverage of external knowledge from suppliers and upstream partners can also be very important in this sector with long value chains. Awareness of and engagement with the market is a key element of the successful exploitation of knowledge. Indeed, these HTNVs, as suppliers themselves, should perhaps consider what they have to do to the knowledge assets to make the knowledge they provide more easily assimilated by their customers.

7.8 Enablers of the leverage of knowledge through the ACAP process

This study has found that key internal enablers of the ACAP process are a) experiential knowledge, b) social capital, c) market awareness, which together impact on the extent of firm's knowledge search, d) organisational culture and governance which in turn influences e) social integration mechanisms, f) investment of resources and g) knowledge management. Key external enablers are a) regimes of appropriability and b) power relationships. The impact of enablers on the dimensions of ACAP are summarised in table 7.14.

7.8.1 Experiential knowledge

This exploratory research has found that the ACAP processes of all cases have benefited from experiential knowledge and this can be demonstrated in all aspects of the ACAP process from knowledge acquisition to exploitation. The cases where the founders have significant experiential knowledge (cases D, E and F) prior to foundation, the young firm behaves as if it is a more mature firm, and anticipates situations that it believes will occur and can be seen to be proactive. In other firms where management teams have less experiential knowledge at foundation (cases B, H and G), the firm can be seen to draw significantly on the experiential knowledge of board members which have been recruited. Where cases are founded on the basis of scientific discoveries from academia (cases B, C, G and H) the prior academic research experience of the founders is vital for the absorption

Table 7.14 Growth challenges and enablers of the leverage of knowledge through the ACAP process

Growth challenge (cases A-I)	**Dimensions of Absorptive Capacity**			
	Acquisition	**Assimilation**	**Transformation**	**Exploitation**
New product /service development (innovation) (A,B,D,E,F,G,I)	Prior industry knowledge (A,B,D,E,G,I) Networks of academic/clinical contacts(A,B, G) Market awareness (A,B,D,E,F, G, I) Links with customers (A,B,D,E) Existing and new industry Links (A,B,D,E, I) Partners (G) Gatekeeper links (A,B, D, E, I) Links with regulatory network (E) Recruitment of new staff with technical skills (A,B,E) Culture of constant improvement and empowerment (A,E) Extensive knowledge search, including: commisioned market research (A,B,D,E,F,G,I), market research reports (B,F), Focus groups (F), Internet (A,B,D,E,F,G,I), public scientific databases (E), patents/patent databases (A,E,F,G,I) Trade press (A,B,E)	Prior experiential knowledge in industry (A, D,E,F,G, I) Existing networks of academic/clinical contacts(G) Culture of open communication /efficient knowledge flow (A,B, E) Market awareness (A,B,D,E) Links with customers (A,B,D,E) Prior technical training/academic research experience (A,B,E,G,) Culture of constant improvement and empowerment (A,E)	Investment of management time to evaluate opportunities (A,B,D,E,F,G,I) Governance (A) Prior experiential knowledge in industry (A, D,E,F, I) Experiential knowledge of routes to market (G) Investment of resources (A,B,E,F,G,I) Supportive investors with industry knowledge (B,E,F,G,I)	Development Partners (F,G, I) Downstream distribution/marketing partners (F,G,I) Market awareness (A,B,D, E,F,G & I) Development of new services (B) Sales growth (B) Supplier network (B,D) Transformation of links into more formal advisory roles eg Scientific advisory board (G) The market environment and associated demand, lead times (A,G&I) Knowledge management (A,B,F,G,I)
New market development (sectoral) (A,B,D,E,F,G,I)	Networks of existing business links from previous employment (I) Prior industry knowledge (A,D, E, G, I) Networks (A) Academic Links (A) Market awareness (A,B,D,E,F,G, I) Links with Customer (A,B,D,E) Links with marketing partners Industry Links (A,B,D,E,F,G,I) Investor links with route to market (F) Outsourced industry analysis supplier (I) Gatekeeper links (A,D) Recruitment of staff with links to market (B) Extensive knowledge search, including: commisioned market research (A,B,D,E,F,G,I), market research reports (B,F), Internet (A,B,D,E,F,G,I), Trade press (A, B,E)	Outsourced industry analysis supplier (I) Prior experiential knowledge in industry (A, I) Culture of open communication /efficient knowledge flow (A,B, E) Customers (A,B,D,E) Investor links (F)	Investment of management time to evaluate opportunities (A,B,D,E,F,G,I) Transformation of links to customers (A) Prior experiential knowledge in industry (A, I) Governance (A) Market awareness (A,B,D,E,G & I) Supportive investors with industry knowledge (B,E,F,G,I) Investment in the opportunity (A,B,D,E,F,G,I)	Accurate evaluation of new market opportunities (A, B, E) Partners (G, I) (Manufacturing/Distribution/marketing) Market awareness (A,B,D,E,G & I) The market environment and associated demand, lead times (A,B,E,G,&I) Supplier network (B,D) Knowledge management (A,D)

Table 7.14 Growth challenges and enablers of the leverage of knowledge through the ACAP process (continued)

Growth challenge (cases A-I)	**Dimensions of Absorptive Capacity**			
	Acquisition	**Assimilation**	**Transformation**	**Exploitation**
New market development (geographical) (A,B,D,E,F,G,I)	Networks of existing business links from previous employment (A,I) Recruiting staff with links (A, B) Prior industry knowledge (I) Links with distributors in key markets (A,F) Links with SDI (B)	Networks of existing business links from previous employment (A,I) Recruiting staff with links (B) Prior industry knowledge (I) Links with distributors in key markets (A,F) Links with SDI (B)	Investment of management time to evaluate opportunities (A,B,D,E,F,G,I) Transformation of links to distributors, agents (D,F,) Links with SDI (B)	Partners (G, I) (Manufacturing/Distribution/marketing) Market awareness (D, G & I)
Collaborations & partnerships (D,E)	Existing links with customers (E) Links with other firms doing complementary testing (E) Prior experiential knowledge in industry (E) Existing business links(D)	Prior experiential knowledge in industry (E) Existing business links(D)	Governance (D, E) Links transformed into collaboration/partnership agreements (D,E)	Ability to provide joint services (D,E) Joint marketing (D,E) Sales growth Cross-selling opportunities (D,E)
Investment in new production/research facilities /increasing capacity (A,E)	Experiential knowledge (A,E) Existing business links (A, E) Links with local networks (A)	Experiential knowledge (A,E) Existing business links (A,E) Investment of management resource (A)	Experiential knowledge (A) Investment of financial resources (A,E) Governance – ease of decision making (A) Government grants (A,E) Market awareness (A)	Downstream partners (A) Market awareness (A) Ability to assess the market environment and associated demand, lead times (A, E) Ability to service the market opportunity (A,E)
Attaining quality standard/ regulatory authority accreditation or approval (A,B,E,F,I) Working to industry regulatory guidelines (D)	Existing business links (D,E) New business links (A,B, D) Prior experiential knowledge in industry (A, E, I) Regulatory consultants (A,B,F,I) Links with policy makers (B) Regulatory network (E) Customers (A,B,E) Regulatory authority websites (D, E) Links of Chairman (B, I) Links of new Board member (B,I)	Prior experiential knowledge in industry (A, E, I) Regulatory specialists (I) Regulatory network (E) Customers (A,B,D,E) Existing business links (D,E) New business links (A,B, D) Regulatory consultants (A,B,F,I) Investors Links with regulatory experts (F) Links of Chairman (B, I) Links of new Board member (B,I)	Prior experiential knowledge (A, E, I) Investment in implementing the quality standard (A,B,E) Implementing standard operating procedures to meet regulatory guidelines (A,B,E) Recruitment of QA staff (A, B) Links of new Board member (B,I) Building of knowledge stocks (clinical trials) to submit to regulatory authorities for approval (F,I) Building stock of knowledge to submit to regulatory authorities to influence safety testing guidelines (B)	Attainment of quality standard/regulatory approval (A,B,E,F) Links with policy makers/regulatory authorities (B) Customers (A,B,D,E) Distributor partner to make regulatory submission (I)
Raising finance (B,E,F,G,I)	Prior industry knowledge (B,E,F,G,I) Links with local angel networks (E,I) Links of chairman/board members (B, E,I) Links with Scottish Enterprise (B,E,F,G,I)	Prior industry knowledge (B,E,F,G,I)	Transformation of links into investors (B,E,F,G,I) Experience and reputation of management team (E, I)	Investors (B,E,F,G,I)
Sourcing supplier/outsourcing partners (B,D,F,I)	Links with suppliers (B, D, F, I) Prior industry knowledge (D, F, I)	Prior industry knowledge (D, F, I) Contacts/links that can recommend the supplier (D) Verifying technical capability (F) Fit with requirements (I)	Transformation of links to supplier agreement (B,D,I) Fit with resources/shared risk (I) Prior experiential knowledge in industry (D,F)	Development partner (I) Clinical research sites (I) Contract manufacturing partner (F) Supplier of high value consumables (B,D)

Source: Abstraction from cross-case analysis (Dimensions of ACAP – Zahra & George, 2002b ,Cases (A-I) – sample firms within this study

of technical knowledge required for the development of new products and services.

> *"When I first came across them, because I was in the diagnostic field I recognised the potential."* GR2 2009/21

In the life science industry, the development of new products and services is dependent on an understanding of biological processes and decades of prior research in the relevant area. This research has shown that a firm must have an understanding of a particular aspect of life sciences in order to develop a product in that area.

> *"I had the experience from xxx[research institute] to put the new technology into xxx [previous employer], I had previous experience from academia, from the University of xxx and the University of xxx where I used that experience to make the technologies as well what we have here."* ER1 2009/19

Shane (2003) highlights previous job functions as being important for access to knowledge and suggests that R&D personnel and marketing personnel in industry settings and academic scientists in particular are more likely to start venture as their role gives them access to opportunities that others do not have. This is certainly the case in B, H and G, where founders were academic scientists and developed the technology on which the firm is founded. In cases A, D, E and F, founders had previous roles in R&D departments and those individuals currently are responsible for the acquisition of technical knowledge and the creation of new knowledge that benefits the firm.

In a number of cases (A, F, E), founders with prior experiential knowledge in business development and sales were responsible for acquisition of external knowledge. In all cases, respondents have described being able to recognise an opportunity because of their prior experience. Case E is unusual in that some of the founders operate remotely in geographical markets and are responsible for sales in those markets. This case is an example of the benefit of prior personal sales experience and reputation in target markets. This evidence concurs with Shane (2003) and Von Hippel (1986), who highlight the importance of previous marketing experience as they have access to customers who provide knowledge about problems with existing products and services, their needs and preferences.

This study also finds evidence to suggest that prior experiential knowledge can also be seen to facilitate the transformation process. Experiential knowledge within the firm is a key enabler which allows the management team to assess the value of particular external knowledge, enabling it to be combined with internal knowledge stocks. All cases within

this study demonstrate evidence that experiential knowledge of the industry enables take technical knowledge such as published clinical data and interpret that in combination with other data to create market knowledge. In dynamic high-technology industries, where no market currently exists and no products already in the market, estimation of future commercial exploitation can only be done by individuals with industry knowledge. Previous experience within the industry, an understanding of the industry dynamics, and what is required to make a particular venture work, enables decision making with more confidence, possibly with less need for the acquisition of further knowledge. This existing knowledge about the industry is very tacit knowledge picked up over many years and cannot be attributed to a single source.

The ability to source knowledge is a key enabler to the initial element of the process, and therefore impacts on all other stages. Awareness of the types of knowledge the firm will require and understanding knowledge gaps in knowledge is the first step of establishing knowledge requirements. Prior knowledge of working in the industry assist management to fast track this so that they are proactively establishing links required and in most cases, the firms in this study form a specific part of a value chain within the life science industry and are not directly involved with the final stages of the global value chain where the majority of the value is created. Therefore, the down-stream value of the knowledge process within these firms is very much dependent on the partners they make agreements with. The costs of development and the lack of finance often necessitate early risk-sharing partnerships. Prior experiential knowledge assists firms with timing of establishing these partnerships and optimising the value for the firm, as described by case G:

> *"do they provide a strategic fit for the business? I'm not saying turn off their enthusiasm, but haven't to become captive to them...and I've been there"* GR1 2009/28

> *"they [a competitor] are selling a variety of kits but they are not making any money because they haven't got their route to market worked out."* GR1 2009/15

A number of respondents described utilising experiential managerial knowledge to establishing particular routines in their current firm in an attempt to replicate or prevent the occurrence of a similar situation. See example below from cases D and E.

> *"A certain part of that business [previous employer] was too big to manage. So we developed streamlined systems here to take away all of the problems that can occur, that we had the history of. When you get to a certain size in a company, if you identify a problem, sometimes you can't fix it. So you put a sticking plaster on it because the way that your whole system surrounds it would be too much to change everything around it…We[in case E] were able to develop the system to manage that."* ER1 2009/12

> *"My experience is that when you get pure testing people, and pure R&D people, when the R&D guys develop it, the testing guys are so busy doing the testing that they can't get it in and you have this disconnect. This barrier effect:*

> *'They're R&D people' and 'They're testing monkeys', so barriers are created and that stops the product going from R&D and into revenue so I like to run it all in the one pot."* ER1 2009/37

> *"Both xxx and I have always worked the way we do now. We know what not to do because we've seen other people do it. We're always very open with clients we don't hide anything. We are always very transparent. We always do what we say we will do, which was not always the case at previous companies."* DR1 2008/22

Similarly, cases (D, F & G) described sourcing suppliers based on previous experience. Respondent from these cases describe their confidence in making decisions about selecting a suppliers and subcontractors:

> *"Yes that what we did for xxx[previous employer] so that was finding a manufacturer and sub-contracting it and writing up all the specs and the bill of materials and the test procedures and all that stuff was second nature really"…"We knew a lot of the suppliers from our xxx[previous employer] days others we've come across since then so it's a mixture of new and old contacts"* FR1 2008/15

> *"In a previous company, we've had contracts in place with xxx [a supplier] pretty close by and they've not delivered so we don't bother."* DR1 2008/8

> *"We knew a lot of that already because we had done that before….And we basically use xxx[a supplier] because they sort everything out for you"* DR1 2008/16

This section has highlighted that possessing experiential knowledge enables HTNVs to leverage new external knowledge to resolve growth challenges. These findings are consistent with the importance of experiential knowledge discussed in the entrepreneurship section of Chapter 2 and ACAP in Chapter 3.

7.8.2 Social Capital

Evidence from this study highlights the importance of social capital as an effective mechanism for HTNVs to increase their ACAP. Section 7.4.4 outlined the types of social capital that were found to assist the leverage of external knowledge. However, a key finding of this study is that not only does social capital enable acquisition of external knowledge in terms of accessing the knowledge and recognising the value of that knowledge, but also the assimilation of that knowledge, as links assist with interpretation of that knowledge. As a result, effective networks and links increase the speed of acquisition and assimilation and enable the firm to respond to market opportunities faster. Evidence of how social capital enables the leverage of knowledge by HTNVs is presented in detail in section 7.9

7.8.3 Organisational culture and governance

- *Culture*

This study highlights three aspects of the role of culture in the leverage of knowledge by HTNVs. Firstly, by creating an environment where learning and innovation is valued is

important, all staff are encouraged to develop behaviours that will spot opportunities and resolve challenges for the firm. This is consistent with the views of Collis (1994) who suggests that the ability to establish an environment that encourages such learning is a resource. Secondly, a culture of empowerment was seen to encourage staff to act upon the knowledge they had acquired. Thirdly, a culture of effective communication and knowledge sharing across the organisation impacts on the ability of acquired knowledge to reach the parts of the business where it is required. Communication is covered in more detail in section 7.8.4. Recruitment practices were also found to impact on the culture of the firm, by recruiting particular types of individuals that are likely to proactively acquire, assimilate and share knowledge to enhance the firm's competitive advantage. A number of cases have specifically recruited staff on this basis, emphasising the importance of a culture of constant improvement, as described by a respondent from case E:

> *"…we have an operations meeting where these things can be brought up, but because there isn't a lot of us, we tend to just do it in the office as well, so there is ad hoc mechanism. But generally there is a meeting where people can come and say anything and the culture that we have here is that if people see anything, they can say anything to improve. We have a completely open culture. And all these people here were selected because of their ability to be that sort of person."* ER1 2009/34

These three aspects of organisational culture combine to impact on the ability of HTNVs to effectively leverage knowledge.

- *Governance*

The governance of firms is identified by this study as an important enabler of the transformation process and the ability quickly to direct appropriate resources to the opportunity or threat identified by the assimilation of knowledge. Empowerment of staff to routinely seek and act upon opportunities and solutions to challenges, up to a certain cost level, enables faster responses, cost efficiencies and often allows the firm to capitalise on an opportunity ahead of the competition. For example, case E allows product development up to a certain level without board approval:

> *"If it's a wee thing like xxx we don't need the board to make that decision, it is just done under the general running of things. If it is a much bigger thing, anything that would cost more than £5k would probably need a wee bit more… it is in our investment agreement that we need to go to the board for that."* ER12009/34

The window of opportunity may only be present for a short period of time and moving quickly is key to maximising the return for the firm. The governance of case F, and the manner in which it was spun out of an existing company with the backing of shareholders with access to appropriate distribution channels, had a major impact on the firm's ability to respond quickly and commercially exploit the external knowledge it acquired in a very

short period of time. Similarly, Case I highlights the ability of the board to respond quickly outwith scheduled board meetings:

> *"we have a board meeting every month and if something exceptional comes up, I'll phone people but we talk, xxx[Chairman] and I talk every day and I talk to xxx[CFO] pretty much every day as well…so getting things approved and done is easy and straightforward."* IR12009/26

The governance of Case A, that does not have external investors, allowed the firm to use cash reserves to fund the exploitation phase of the ACAP process, and to invest quickly in a quality standard implementation and the production scale-up to allow the firm to service the new market. In contrast, where firms have external investors, firms can be seen to gather a 'dossier of evidence' to justify potential investment in a given opportunity, but while board members can enhance the firm's ability to leverage knowledge, the governance of the firm can also be a barrier to the firm's ability to do so.

7.8.4 Social integration mechanisms

Effective communication and dissemination of knowledge has been identified as an important precedent to assimilation of external knowledge (section 7.5.3), consistent with the views of Cohen and Levinthal (1990) and Zahra and George (2002b). However, this study also shows that by communicating effectively with staff, staff are aware of the focus of the firm and are more likely to recognise the value of external knowledge, thus enhancing the acquisition dimension of the firm's ACAP, as described by a respondent from case A:

> *"That is done through staff briefings on a regular basis. Every two weeks, all the staff get together and we tell them what news is of interest, what business is hot and what is not, and then every time there is a major change in what we're doing, we actually have a special session on that specifically. And every year, we lay out the plans for the coming year and that includes rolling forward. We have basically a three-year rolling plan."* AR12008/30

This reinforced the importance of a culture that encourages the sharing of knowledge.

7.8.5 Market awareness

This study demonstrates that market awareness can have a significant impact on the commercial outcomes of the ACAP process (see section 7.7.2). External knowledge from customers has been shown to be vital to exploitation of innovations. As part of global value chains, HTNVs need fully to understand their position in the value chain and key actors that they need to build relationships with in order to achieve a commercial return. As

product development costs increase and sourcing investment becomes more challenging, risk sharing collaborations with downstream partners is having more of an impact on the commercial return on investment made by HTNVs. In building these relationships across the value chain, HTNVs must consider what they have to do to their knowledge assets to make the knowledge they provide more easily assimilated by their customers. Since the ACAP of some organisations and the market awareness of others is not always optimal, links, networks, and intermediaries are key to effective transfer of knowledge as they enhance the ACAP of some and also encourage the market awareness of knowledge suppliers.

7.8.6 Investment of resources

In all cases, the leverage of knowledge has required significant investment of resources. Although the financial investment required to build new capabilities and knowledge assets is a tangible cost to the business, and raising finance is a major challenge to entrepreneurial HTNVs. However, HTNVs have to invest considerable resources in terms of management time at each dimension of the ACAP process in order to successfully leverage knowledge. Particularly evident at the transformation dimension, management capacity to allocate time to evaluating new opportunities by combining new knowledge with existing knowledge stocks is a factor in the leverage of external knowledge.

7.8.7 Regimes of appropriability

This study finds that a market environment in which firms operate has a major impact on the outcomes of the ACAP process, in particular the transformation and exploitation dimensions. Firms can be seen to make investment in developing assets or capabilities dependent on the perceived return on investment. Zahra and George (2002b:196) called this the regime of appropriability, referring to "the institutional and industry dynamics that affects the firm's ability to protect the advantages of (and benefit from) new products and processes. Zhara and George's (2002b) model indicated that regimes of appropriability only effected the exploitation of knowledge, however the findings of this study are more consistent with the view of Todorova and Durisin (2007) who suggested that it impacted on all the dimensions of ACAP. In the life science industry, product development is a long

and expensive process with a high risk of failure. That said, firms can protect their intellectual assets and if successful, can make a significant return on investment. However, it has been highlighted that HTNVs in the life science industry are part of a value chain and the successful commercialisation of innovation can be in the hands of downstream partners and dependent on regulatory approval. The management team of HTNVs will undoubtedly consider the likelihood of being able to create and protect a competitive advantage for the firm when considering acting on a market opportunity.

7.8.8 Power relationships with value chain partners and customers

As discussed earlier in section 7.7.2, the new organisational forms which are created as an outcome of the ACAP process (see table 7.13), have a significant impact on the successful commercial exploitation of knowledge. By utilising social capital to build relationships with potential partners, HTNVs can better understand industry value chain dynamics and broker better deals that maximise the exploitation opportunity.

7.8.9 Knowledge management

Knowledge management is particularly relevant to the exploitation dimension of the ACAP process, although it is evident that the social intregration mechanisms that enable knowledge to be transfer from individuals to the group as key to enabling the knowledge management process to begin.

7.9 How does social capital enable HTNVs to leverage knowledge to resolve growth challenges associated with critical events?

Earlier analysis highlighted that the resolution of key challenges that HTNVs faced at the critical events enabled the firm to grow and develop. Furthermore, this study draws attention to the importance of tacit knowledge that can only be accessed through experience or through building relationships, and has established that social capital is a key means by which HTNVs access and acquire external knowledge they need for growth. This section describes the results of the next stage of analysis which explored the types of relationships discussed by sample firms as providing access to the knowledge they needed to resolve the challenges. These are discussed in the following pages and summarised in table 7.15. The detailed data tables are presented in Appendix 4, in tables A-4(a)–A-4(g).

Table 7.15 Types of social capital as enablers of resolution of growth challenges

Growth challenges (type of innovation)	Types of social capital	D/I	Pre/post	Knowledge acquired	E/T
New product /service development (product innovation)	Academic links	D &I	Pre & Post	TK	E&T
	Existing business links	I	Post	MK ,RK	E&T
	New business links	D&I	Post	MK	T
	Special interest groups	I	Pre & Post	RegK, MK	E&T
	Local networking group	D	Post	TK, MK	T
New market sector development (market innovation)	Existing business links	I	Post	MK , RegK TK , CK	T
	New business links	D&I	Post	MK , RegK	T
	Links with gatekeepers of pharma networks	I	Post	MK, TK	T
	Special interest groups	I	Post	MK, TK	T
	Local networking groups	D	Post	MK	T
	Investor links	D&I	Post	MK, RK	T
	Director links	D	Pre	MK	T
	Chairman links	I	Post	MK	T
International market development	Existing business Links	I	Pre	MK, IK	T
	Links with SDI	I	Post	IK	T
	New business links	I	Post	RegK	E&T
	Personal links	I	Post	MK	E&T
	Chairman/Director links	I	Post	MK, RegK, IK	T
Collaborations (new org. forms)	Academic links	D	Pre	TK	E&T
	Existing business links	D	Pre	MK, TK	T
Attaining quality standard/ regulatory authority accreditation or approval (Process innovation)	New business links	I	Post	MK, RegK	T
	Existing business links	D&I		MK, RegK	T
	Links of chairman	D	Post	RegK	T
	Links of new board member	I	Post	RegK	T
	Investor links	D&I	Post	RegK	T
	Links with policy makers	D	Post	RegK	T
Raising finance	Local network links	D	Pre	Mng K	T
	Local business angel network	D	Pre	Mng K	T
	Links of the Chairman	D	Post	Mng K	T
	Investor links	D	Post	Mng K	T
	Existing business contacts	D&I	Pre	Mng K, MK	T
Investment in new production facilities/ increasing capacity (process innovation)	New Business Links	I	Post	MK TK RegK	T
	Existing and new business links	I	Pre	MK, TK, RK	T
Sourcing supplier/outsourcing partners (supplier innovation)	Academic links	D&I	Post	TK,MK	T
	Existing business links	D&I	Pre	TK	T
	New business links	D&I	Post	TK, MK	T
	Links with policy makers	D	Post	RegK	T

Types of knowledge : Explicit/Tacit (Nonaka, 1994), Geographical location of link: D= domestic, I= International
Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=managerial knowledge, RK=regulatory knowledge, IK= Internationalisation knowledge,
Timing of relationship development: Pre = pre-foundation, Post = post-foundation

Source: Summarised from tables a-h in Appendix 4

7.9.1 How does social capital enable firms to leverage external knowledge to facilitate new product development?

This study has found that there are three main types of social capital that assist HTNVs with the leverage of external knowledge in relation to new product and service

development (NPD): *academic links, existing business links, and new business links*. These are summarised in table A-4 (a). This study highlights that firms proactively join special interest groups and local networking groups in order to build and maintain these types of connections and relationships which provide access to external knowledge. Although HTNVs have a high knowledge base within the firm, they do not always have the complex combination of knowledge required to respond to a new market opportunity.

Academic links are seen to assist with NPD in a number of ways. The majority of technical and marketing staff in HTNVs are educated to higher degree standard (PhD) in one or more of the life sciences. Throughout that education process, relationships have been forged, which in many cases has been maintained. Being part of that community, it is easy for these individuals to build new links with academic research groups as the firm requires new expertise, as they share the language of that network and have the ACAP which enables understanding of the scientific advances in the field. In this study, academic links have been shown to provide access to knowledge, technical expertise and know-how, along with access to specialist facilities and equipment. In this way, academic links enable both fundamental and applied innovation, providing access to scientific advances, acting as advisors in screening of compounds or in the production of synthetic analogues for drug development. Furthermore, academic centres of excellence can also provide access to specialist expensive equipment that a HTNV could not afford to invest in itself. In addition, the technical expertise to optimally use this equipment is also on site and provides the firm with an efficient service. Clinical research groups facilitate with clinical applications of products (F and G). Although technical knowledge is available through published sources such as scientific journals and public databases, case A demonstrates that building relationships with academic groups can also provide the firm with this knowledge in advance of it becoming explicit, thus giving the firm time to develop products using this innovation and therefore a competitive advantage. These links can lead to more formal arrangements such as licenses where a patented knowledge asset is of significant value and a more formal agreement is required to enable the exploitation of that innovation.

Business links are key to ensuring that the firm is developing products and services that meet the requirements of the market. Business links predominantly provide market

knowledge including the dynamics of the industry. When developing new products which may be intended for a new market, often the firm need to make *new business links* with potential customers. As previously discussed, as HTNVs operate in fast-moving markets where there is little readily available market research about customer requirements, size of market, the firm's most efficient method of establishing the anticipated market demand, is to talk directly with the firms they think would use the services or products. This is discussed in detail in the next section.

Firms use *existing business links* to access market knowledge. By using relationships where trust has already been established, firms obtain more valuable information because these links provide assistance with assimilation of knowledge. HTNVs can more effectively understand what the issue means to the customer and can discuss how the firm can respond. In addition to market knowledge, business links have been seen to provide valuable regulatory and technical knowledge, which also enables the firm to develop successful products and services that conform to both technical and regulatory requirements. This understanding takes the firm much further forward in creating a solution that will be valued by customers. When the firm is part of an established network of business links in a niche industry, there is often regular contact with competitors at specialist conferences, so this is the way to evaluate the competitor offerings and establish gaps in the market.

7.9.2 How does social capital enable firms to leverage external knowledge to facilitate new market development?

This study has found that there are three main types of social capital that assist HTNVs with the leverage of external knowledge in relation to new market development: *new business links, gatekeepers in large companies, special interest groups* and recruitment of new staff with appropriate social capital is a key mechanism for proactively addressing anticipated knowledge requirements. These are summarised in table A-4 (b). As all the cases in this study operate in global industry, this market development is across multiple geographies.

When evaluating a new market opportunity in a dynamic high-technology industry where there is little available market research, access to market knowledge, including the structure of the value chain, is vital to understanding whether the opportunity is worth pursuing. The evidence from cross-case analysis illustrates that establishing *new business links* within the route to market, including potential new customers and distributors, provide a combination of market, technological and regulatory knowledge, enabling a more accurate interpretation of the market dynamics, trends and developments, customer requirements, entry barriers. This highlights the importance of market orientation to market development in HTNVs. Furthermore, being a highly regulated industry, new markets can have different regulatory requirements and quality standards, creating entry barriers that have to be surmounted before the firm can operate in that market. Case A, explored in detail in the previous chapter, highlights the importance of building relationships with potential customers in new markets.

As HTNVs often work with much larger pharmaceutical companies, it is important to establish connections with key individuals that act as *gatekeepers* for the activity in question. In relation to establishing new business relationships, cases A and D described the need to understand who the key decision makers were and find ways of influencing them, through being seen as leaders in the field, providing solutions to vital problems and developing trust between them. Case D highlighted that as trust was established and more business was done between the two firms, there was less involvement of the gatekeeper and more direct contact with individual scientists in the pharmaceutical companies.

The evidence from the cross-case analysis also suggests that firms forge *new business links* through joining *special interest groups* and networks and attending specialist conferences for their industry niche. This is also a route to access contacts in potential customer organisations and build relationships with them in order to understand the new market.

Firms in this study can be seen to leverage their existing networks and reputation to make *new business links* in the areas required. In three firms in this study, new members of staff were recruited because of their *existing business links* and contacts in the industry to facilitate the building of relationships with potential customers. Using their social capital, the firm can acquire market knowledge it did not previously have access to. Cases A and G recruited well connected individuals to the position of company Chairman to provide

credibility in the new market and open doors for the firm. The *connections of new board members and investor representatives* also provided knowledge about routes to market.

7.9.3 How does social capital facilitate the leverage of knowledge in relation to new international market development?

As all the firms in this study operate in global niche markets, market development is essentially internationalisation by the nature of the markets. This section analyses the social capital highlighted by case firms in relation to internationalisation. Links can be seen to be of particular importance in assisting the firm to internationalise as summarised in table A-4 (c). *Existing business links* provided contacts with potential customers which for a number of cases (A, D, E, F & G) led to the first international business for the firm. Existing business and personal links also provided firms with contacts that became distributors and agents. A number of firms described building relationships with *Scottish Development International*, the international development arm of Scottish Enterprise. This relationship provided the firms with valuable initial contacts in overseas markets. Developing new international market necessitated the development of *new business links*, but these were often initiated through an existing contact in a special interest group or an intermediary. The findings of this study fit with the body of literature relating to the role of networks and social capital in internationalisation (e.g., Chetty & Wilson, 2003; Coviello, 2006; Coviello & Munro, 1997).

7.9.4 How does social capital facilitate the leverage of knowledge in relation to the development of collaborations?

The evidence from this study suggests that relationships are the building blocks which, once cemented and developed, can lead to more formal partnerships and collaborations. This is summarised in table A-4 (d). This study provides evidence from cases D & E where social capital, in the form of existing relationships between members of the management team and individuals in the other organisations, are developed and transformed into more formal collaborations. Through these relationships, the firm are able to understand the organisation's capabilities and leverage their technical and market knowledge to jointly provide services to the marketplace that neither firm could provide alone. As relationships are deepened, the firm builds up stock of knowledge that is specific to that relationship, proprietary knowledge which enhances the competitive advantage of the services provided

by the partnership, which concurs with Dyer and Singh's (1998) notion of partner specific ACAP. The evidence from this study also concurs with Gulati (1995) who found evidence that indirect ties lead to direct ties, and firms with common ties were more likely to form alliances and collaborations through these weak links.

7.9.5 How does social capital facilitate the leverage of knowledge in relation to the investment in new production facilities?

This study found that when major investment was required to capitalise on a market opportunity, the knowledge antecedent that precipitated the decision to enter the market has often been accessed through the social capital of the firm. However, as the firm plans the investment in facilities it needs further knowledge of customer requirements. As firms build *relationships with customers and potential customers*, they understand the volumes of product required, and the quality standards that they will have to operate to, and can therefore hone their plans for expansion based on the market knowledge they have received. Furthermore, case A learned of the liquidation of a local firm and the resulting auction of production equipment through a *local network*. These findings are summarised in table A-4 (g).

7.9.6 How does social capital facilitate the leverage of knowledge in relation to the raising of finance?

Five firms in this study raised external finance. The cross-case analysis found that the social capital of HTNVs did not feature strongly across all firms in relation to the challenge of raising finance. The findings are summarised in table A-4 (f). Four cases (B, E, F & I) used contacts supplied by Scottish Enterprise to make contact with business angels and VC investors. One firm used the chairman's connections to approach investors. Another case found a potential investor in existing business connections with market knowledge regarding routes to market in key geographical markets. This result may be due to the lack of appropriate connections by case firms rather than the lack of importance of social capital in fundraising.

7.9.7 How does social capital facilitate the leverage of knowledge in relation to the achieving regulatory approval or quality standards?

This study has found that there are four types of social capital that enable the leverage of external knowledge by HTNVs in relation to achieving regulatory approval or accreditation and implementing quality standards: *existing business links, new business links, Links of the chairman and board members, and investor links.* These are summarised in table A-4 (e). For some HTNVs such as case E, founders have extensive links within the industry and know that they will be required to operate to a regulatory requirement. For firms entering new markets,(e.g. case A) where they do not have existing business links, there is evidence of new links being forged to understand the regulatory requirements of the market. In Case F, one of the firm's investors provided the firm with knowledge that facilitated regulatory submissions. In Cases B and I, a connection of the chairman with regulatory experience became a board member and brought regulatory knowledge to the firm. Although regulatory guidelines are explicit and freely available, the interpretation of regulatory knowledge is tacit and appropriate social capital can greatly assist in understanding how to implement it appropriately.

7.9.8 How does social capital facilitate the leverage of knowledge in relation to the sourcing of suppliers?

This study has found that there are three main types of social capital that assist HTNVs with the leverage of external knowledge in relation to sourcing suppliers: *academic links, existing business links, and new business links*. These are summarised in table A-4 (h).This study found that HTNVs that provide services utilising scarce, high-value consumables are extremely dependent on reliable supply in order to provide their services effectively. Therefore, their reputation can be built by building strong links with suppliers. In case B, a new member of staff who had extensive links with the suppliers required was recruited. Whereas case D found that by gaining the trust of suppliers, they were then able to sign more formal distributor agreements that made supply more reliable, other firms used existing business links to source suppliers of both research and manufacture. Another case is addressing the challenges of supply by building links with policy makers, in order to influence policies which currently restrict availability of supply.

7.10 Conclusions and implications

In this chapter, the leverage of knowledge by HTNVs at identified critical events has been analysed. Cross-case analysis reveals that HTNVs can face common challenges at critical events, albeit in varying combinations, depending on the context of the critical event. Key growth challenges were found to involve the three key drivers of small firm growth (Innovation, Internationalisation and Entrepreneurship), and all of five of Schumpeter's (1934) types of innovation.

Critical events were found to have been precipitated by knowledge antecedents, which proved, when combined with existing stocks of knowledge in the firm to be 'tipping points' to the firm recognising an opportunity. This study finds that this triggers a cascade of further knowledge acquisition by HTNVs to resolve a series of challenges associated with responding to these opportunities.

Using the framework of ACAP, this chapter has explored the leverage of knowledge at the dimensions of acquisition, assimilation, transformation and exploitation:

Acquisition of external knowledge

This study finds that the types of external knowledge required by HTNVs to provide solutions for some of these growth challenges are: market, technical, managerial, regulatory, internationalisation and relational. Furthermore, this study points to the significance of tacit market knowledge for HTNVs, particularly market knowledge relating to the global value chain in which the firm operates.

Examination of the roles within the firms that acquire different types of knowledge highlights the crucial position of key individuals whose role it is to acquire knowledge for the firm, and points to the importance of prior experience to enable them to recognise the value of knowledge, and social capital to enable access to the sources of relevant tacit knowledge. Analysis of the types of social capital and the types of knowledge that they elicit feed into the understanding of how social capital facilitates the resolution of growth challenges.

Assimilation

Cross-case analysis of knowledge assimilation by HTNVs to resolve growth challenges reveals that assimilation of knowledge occurs at an individual level and at firm level. A key element of a firm's successful understanding of the implications of external knowledge involves the effective dissemination of knowledge to the appropriate parts of the business. In examining the routines by which external knowledge is communicated throughout the firm, this study finds that small HTNVs tend not to require formal communications mechanisms. However, this changes as the firm grows. This study provides significant evidence that social capital, experiential knowledge and intra-organisational communication are enablers of the firm's ability to assimilate external knowledge.

Transformation

Evidence of the transformative capability within the firm in this study are decisions made following assimilation of external knowledge, which have led to the development of capabilities that resolve the challenges associated with the critical events which enhance the growth and development of HTNVs. These include decisions about the development of new products and services to meet market opportunities (all cases), positioning of these products and services, collaborations to meet market opportunities, expansion of facilities to meet anticipated demand in new markets, implementation of quality standards, seeking regulatory approval to surmount barriers to entry, decisions about market entry.

Transformation of knowledge was found to occur among teams with management responsibility, and the level of seniority of decision-making depends on the significance of the decision being considered and the investment required to implement it. Enablers of transformation are prior experience and a combination of the culture and governance of the firm.

Exploitation

Exploitation of external knowledge is evident in all cases within this study, although there is seldom an immediate growth outcome as a result of a single iteration of the ACAP process. Firms can demonstrate the exploitation of that knowledge in a number of new products developed as a result of the ACAP process. However, an outcome of the ACAP

process is often that further external knowledge is required to enable a decision to be made, or that a stock of knowledge must be developed to capitalise on an opportunity. A key finding from this study is that the ACAP process is an iterative and cumulative knowledge process within the firm. This study also highlights that the outcome of the ACAP process is often a new knowledge asset that adds value to the firm and can be utilised in the future, thus demonstrating the importance for HTNVs of building and managing stocks of knowledge.

Enablers of the ACAP process

This study has found that key internal enablers of the ACAP process are a) experiential knowledge, b) social capital, c) organisational culture and governance, d) social integration mechanisms, e) market awareness, f) investment of resources and g) knowledge management. Whereas, regimes of appropriability and power relationships in the market environment within which the firm operate also impacts on the firm's ability to leverage commercial returns form the knowledge it acquires. The evidence from this study suggests that a number of enablers need to be present, working in syncopation, for optimum leverage of knowledge by HTNVs.

In particular, this study demonstrates the importance of social capital as an effective means for HTNVs to increase their ability to leverage knowledge. Social capital impacts on both acquisition of external knowledge in terms of accessing the knowledge and recognising the value of that knowledge but also the assimilation of that knowledge, as links assist with interpretation and the relationship with trusted links. As a result, social capital increases the speed of acquisition and assimilation and enables the firm to respond to market opportunities faster.

Linked to a number of the above points, it is evident in the findings that developing social capital of the firm, both upstream and downstream in the value chain, is crucial for the success of these HTNVs and building relationships outwith the firm is an important activity.

These findings are discussed in relation to the literature in the following chapter.

Chapter 8

Discussion of key findings and conclusions

8.1 Introduction

This chapter represents the culmination of the work presented in previous chapters. It concludes the thesis by summarising its key findings and using them as a basis to derive propositions. The chapter outlines how the findings from this thesis answer the research questions conceptualised in Chapter 4 and highlights how these findings shed new light on the leverage of knowledge by HTNVs.

The research presented in this thesis was carried out with the specific intent to develop a better understanding of how HTNVs acquire and utilise knowledge to enable the resolution of growth challenges. The literature review highlights the role of critical events and their associated challenges for the growth of HTNVs. The efficient leverage of knowledge is vital to finding solutions to these challenges in order to enable HTNVs to grow.

The primary research questions which drove the line of enquiry in this exploratory study were:

- *How do HTNVs leverage knowledge at identified critical events to resolve growth challenges?*
- *What are the temporal aspects of knowledge leverage by HTNVs at critical events?*

Furthermore, given the complex interwoven relationships between the key drivers of growth for HTNVs identified in Chapter 2, this study takes a holistic approach to key integrated entrepreneurial processes. The problem-solving role of ACAP highlighted in Chapter 3 makes ACAP an appropriate lens through which to investigate the research questions. As described in Chapter 5, taking a qualitative processual approach provides a more in-depth understanding of the manner in which HTNVs leverage knowledge as the process unfolds over time. Chapters 6 and 7 have presented the findings of how sample firms leverage knowledge at identified critical events to resolve growth challenges, focusing on the processes at each dimension of ACAP.

A number of key issues have emerged from Chapter 7 and these are discussed from the basis of the empirical findings from this study, the extant literature in the field and the author's knowledge of the industry. From these key findings, propositions are derived with the objective of advancing theory. The most important contribution of this study has emerged from incorporating a number of other findings relating to enablers of ACAP and temporality of the ACAP process, which is that *the pace and efficiency of the leverage of knowledge through the ACAP process at a critical event is maximised when HTNVs have a number of enablers present and operating synergistically*. The second key contribution is that *HTNVs that are aware of social capital as an enabler of ACAP build relationships that facilitate the timely acquisition and faster leverage of knowledge at critical events*.

A number of key issues have emerged from this study, leading to these contributions and these are discussed in the following order:

Firstly, section 8.2 frames the discussion of the findings of this research in the context of the complexity of the challenges faced by HTNVs at critical events. Highlighting the appropriateness of the holistic approach to key integrated entrepreneurial processes, this study proposes that HTNVs that have the key drivers of growth (innovation, internationalisation and entrepreneurship) in syncopation can effectively resolve challenges at critical events and enable the growth and development of the firm. The knowledge requirements of HTNVs are equally complex and therefore the process of leveraging knowledge they require to find solutions transcends the functional boundaries of the firm. This study highlights six different types of knowledge (market, technical, managerial, regulatory, internationalisation and relational) required by HTNVs to transition through growth challenges to the next stage of growth.

Secondly, this chapter addresses the research questions by proposing a holistic processual model of absorptive capacity (Figure 8.1, page 298) which illustrates how HTNVs leverage knowledge to resolve their growth challenges. This model highlights the key role of individuals in recognising the value of knowledge, introducing three components of individual-level ACAP (recognising the value, acquisition and assimilation). It highlights the relationship between individual- and firm-level ACAP introducing the construct of group assimilation. This model also illustrates how the ACAP process builds the firm's

knowledge stocks, which in turn further impacts the firm's ACAP. The model highlights that the leverage of knowledge requires multiple enablers operating together at each dimension to maximise the pace and efficiency of knowledge leverage (see sections 8.3 and 8.4). How this study extends existing models of ACAP is highlighted in section 8.8.1.

The enablers of ACAP, which were identified in Chapter 7, are discussed in section 8.5, highlighting that individual enablers are not effective in isolation. The enabling role of social capital, in the timely acquisition and the assimilation of that knowledge, is particularly evident, featuring prominently for all growth challenges. The types of social capital are identified, highlighting that different types of relationships are required to assist with different challenges. In particular, the social capital of board members is highlighted as a valuable mechanism for HTNVs to leverage knowledge rapidly to resolve challenges they face. This study also highlights the additional challenge for HTNVs of investing time and resources in building an optimum level of social capital, in appropriate parts of the value chain and appropriate times in order to maximise the speed of growth of the firm.

Fourthly, incorporating all the findings of this study, the temporality of the ACAP process is discussed in section 8.6, making the most important contribution from this research. This study highlights that due to the short windows of opportunity in dynamic high-technology markets, the timeliness of new knowledge acquisition and the speed of leverage of knowledge through the ACAP process have an impact on the firm's ability to resolve challenges associated with critical events that impact on the growth of the firm. Furthermore, the investment in the time taken by HTNVs to proactively put in place the enablers of ACAP have an impact on the pace and efficiency of knowledge leverage at a critical event.

In section 8.7, the contributions of this study to current knowledge are discussed in relation to the fields of small firm growth and ACAP. The implications for policy makers and practitioners are also highlighted. Lastly, this thesis concludes with a discussion of the limitations of this study and suggestions for future research directions.

8.2 Complexity of knowledge requirements of HTNVs to resolve growth challenges at critical events

In this study, HTNVs experiencing rapid growth are seen to be dealing with a number of challenges simultaneously, including developing their technology further in product development; market development, predominantly overseas; sourcing suppliers, achieving regulatory accreditation and developing collaborations. All the firms in this study have been international in their outlook from inception and therefore can be categorised as international new ventures (INVs) (Oviatt & McDougall, 1994). However, HTNVs in this study regard internationalisation as an integral part of their market development, not as a separate activity. Instead, these firms evaluate market opportunities based on whether they can service the requirements of that niche customer, the speed to market and the likely return on investment, regardless of their geographical location. Furthermore, in addition to servicing customers in international markets, due to the technical niche of the services required, they also outsource activities themselves to supply partners in geographically distant locations. This reflects the complex global value chains that exist in the life science industry. The findings from this study concur with the view of Jones (1999:15), that "internationalisation is part of and inseparable from the overall growth and development processes of small firms". The interwoven nature of the complex challenges facing HTNVs is articulated throughout the rest of the discussion, reinforcing the integrated entrepreneurship approach taken to investigate the leverage of knowledge. This evidence suggests that scholars exploring the growth of HTNVs should consider these key drivers of growth holistically rather than in a vacuum.

This study finds evidence to suggest that HTNVs have an acute demand for new external knowledge to assist with the resolution of these challenges, which is consistent with the views of earlier work (e.g.,Veugelers, 1997; Morgan & Berthon, 2008). Furthermore, in the context of HTNVs dealing with multiple challenges simultaneously and having to prioritise limited resources to do so, this study finds that the knowledge requirements are equally complex. The knowledge processes support the key drivers of growth and the findings from this study suggest that the knowledge leverage processes transcend functional boundaries and are immersed in the context of the challenges the firm is facing. However, the industry environment is key to all of these drivers and its impact on one

process can affect the others (Liao et al., 2003). Due to the limited resources within the HTNVs, often with fewer than 10 employees, this knowledge has to come from outwith the firm. Following the aforementioned discussion, propositions surrounding the complexity of challenges faced by HTNVs at critical events and their resolution are formulated as follows:

Text Box 8.1

Proposition 1a:	The leverage of knowledge through the ACAP process is determined by the context of the multiple challenges being faced by the firm at critical events.
Proposition 1b:	HTNVs that have the key drivers of growth (innovation, internationalisation and entrepreneurship) in syncopation can effectively resolve challenges at critical events and enable the growth and development of the firm.

This study highlights that due to the complexity of the interwoven challenges that HTNVs face, there is no easy or quick knowledge fix for these firms. This study has found that to provide solutions to the growth challenges the sample HTNVs faced, they require combinations of six key types of external knowledge: *1) market, 2) technical, 3) managerial, 4) regulatory, 5) internationalisation and 6) relational.* This study concurs with the view of Marvel and Lumpkin (2007) and others (e.g., Demsetz, 1991; Shane 2000) that no one single type or source of knowledge is sufficient to enable small firms to capitalise on growth opportunities. This study highlights that even when HTNVs are highly valued for their stocks of technical knowledge, they may still require varying combinations of six different types knowledge to successfully exploit their internal stock of technical knowledge, leading to the following proposition:

Text Box 8.2

Proposition 1c:	HTNVs leverage a combination of knowledge types (market, technical, managerial, regulatory, internationalisation and relational) to resolve growth challenges at critical events.

Tacit market knowledge was found to be of particular importance to HTNVs and as this can only be sourced through building relationships with customers and potential customers in the marketplace, this highlights market awareness as enablers of the leverage of the

leverage of knowledge is discussed further in section 8.3. As the main models of ACAP (Cohen & Levinthal, 1989; Zahra & George, 2002b; and, more recently, Todorova and Durisin, 2007), do not discuss what types of external knowledge are acquired by firms, the findings of this study make a contribution to knowledge by filling a gap in the understanding of ACAP in HTNVs.

8.3 Answering the research questions - ACAP as a process

The research presented in this thesis has been driven by the primary research questions:

- *How do HTNVs leverage knowledge at identified critical events to resolve growth challenges?*
- *What are the temporal aspects of knowledge leverage by HTNVs at critical events?*

In order to answer these questions, this research has taken a processual approach which provides a more in-depth understanding of the manner in which HTNVs leverage knowledge as the process unfolds over time. This approach draws from the descriptive narratives and visual maps in the early analysis (see examples in Chapter 6) to provide an understanding of the sequence of events, and the explanation building in the later analysis helps to build the understanding of how and why the process unfolds as it does.

In answering the research questions, the first important insight that this processual study highlights is the iterative, cyclical and cumulative nature over time of the leverage of knowledge, which builds stocks of knowledge in the HTNVs at each cycle. Secondly, a number of new insights relating to the ACAP process have emerged, adding to the understanding of how the process unfolds and the impact of enablers. These insights fill gaps in the existing models of ACAP, and therefore, this thesis advances a new process model of ACAP (Figure 8.1). Dimensions of this model are outlined in section 8.4, while further discussion of the enablers and temporality of ACAP is provided in sections 8.5 and 8.6 respectively.

8.3.1 The iterative, cyclical and cumulative nature of the leverage of knowledge by HTNVs

As the leverage of knowledge by HTNVs has been shown to be of crucial importance for their ability to surmount the challenges they face at critical events, understanding how these knowledge processes occur contributes to knowledge by facilitating the ability to model the process more accurately.

This study finds significant evidence that the leverage of knowledge by HTNVs is not linear or a single isolated process. The result of assimilation of knowledge is often a realisation that more knowledge is required, and this triggers the search for further knowledge. The analysis of the knowledge antecedents which precipitated critical events in case firms, demonstrate that the assimilation and exploitation of that initial knowledge, which acts as a tipping point, triggers a cycle of knowledge processes as the firm seeks to understand the potential opportunity or threat, and then creates a cascade of further knowledge processes as the firm addresses the challenges associated with capitalising on an opportunity. This is illustrated in detail by Case A in Chapter 6. Furthermore, due to the complexity of the challenges faced by HTNVs, there is evidence that the leverage of knowledge to resolve challenges transcends functional boundaries.

Often, the first few cycles of the ACAP process result in the recognition that further knowledge is required and this then has to be sought. Several rounds of particular dimensions (acquisition and assimilation) of ACAP process are often required to enable a transformation decision to commercially exploit that knowledge. The evidence suggests that the intensity of effort by HTNVs in the search for, and assimilation of, new knowledge may be linked to the determination of the firm to resolve the growth challenge it is facing, which is constituent with Kim's (1998) view of ACAP as a problem-solving capacity. This finding is consistent with notion that ACAP is path-dependent (Cohen & Levinthal, 1990; Van den Bosch et al., 1999; Lane et al., 2006). Findings also echo ideas emerging from Zollo and Winter's (2002) knowledge evolution cycle (Figure 2.2).

Therefore, the findings of this study provide insights to suggest that leverage of knowledge through the ACAP process by HTNVs is cyclical, iterative and cumulative over time, building the firm's stocks of knowledge at each cycle. This is incorporated into a new

model of ACAP (Figure 8.1). This builds on Zahra and George (2002b:188), who note that "the four capabilities that make up ACAP are combinative in nature and build upon each other to produce a dynamic organisational capability" and suggest that "external knowledge undergoes multiple iterative processes before the recipient firm can successfully exploit it to achieve competitive advantage"(:197). However, the majority of ACAP literature, while acknowledging the path-dependent nature of ACAP, tends to present the ACAP process as a single linear process. Todorova and Durisin (2007) do suggest the need for feedback loops in their model of ACAP (Figure 3.5), illustrating that the knowledge acquired and assimilated today impacts the firm's future ACAP. However, no models to date fully explain the iterative, cyclical and cumulative nature of the leverage of knowledge through the ACAP process, or the nature of the cycles. Therefore, this study contributes to the deeper understanding of how small firms leverage knowledge and how the ACAP process occurs over time. From the above discussion, a proposition relating to the nature of knowledge leverage by HTNVs can be made:

Text Box 8.3

Proposition 2:	HTNVs leverage knowledge through the ACAP process in cyclical, iterative and cumulative process over time, building internal stocks of knowledge at each cycle.

8.3.2 A new process model of absorptive capacity

Looking at ACAP as a process enables a more complete understanding of its development. Although ACAP was recognised a set of routines and processes by Zahra and George (2002b), it has been primarily studied as a dynamic capability, missing key process elements that would help develop the construct further (e.g., Easterby-Smith et al., 2008). The model that has emerged from the evidence in this study will enable future research to better evaluate the development of absorptive capacity within firms. Box 8.4 summarises how this new model of the ACAP process advances the field. The dimensions of the proposed process model of ACAP are articulated in section 8.4, while enablers of the ACAP process are discussed in section 8.5.

Text Box 8.4

New insights from a reconfigured processual model of ACAP:

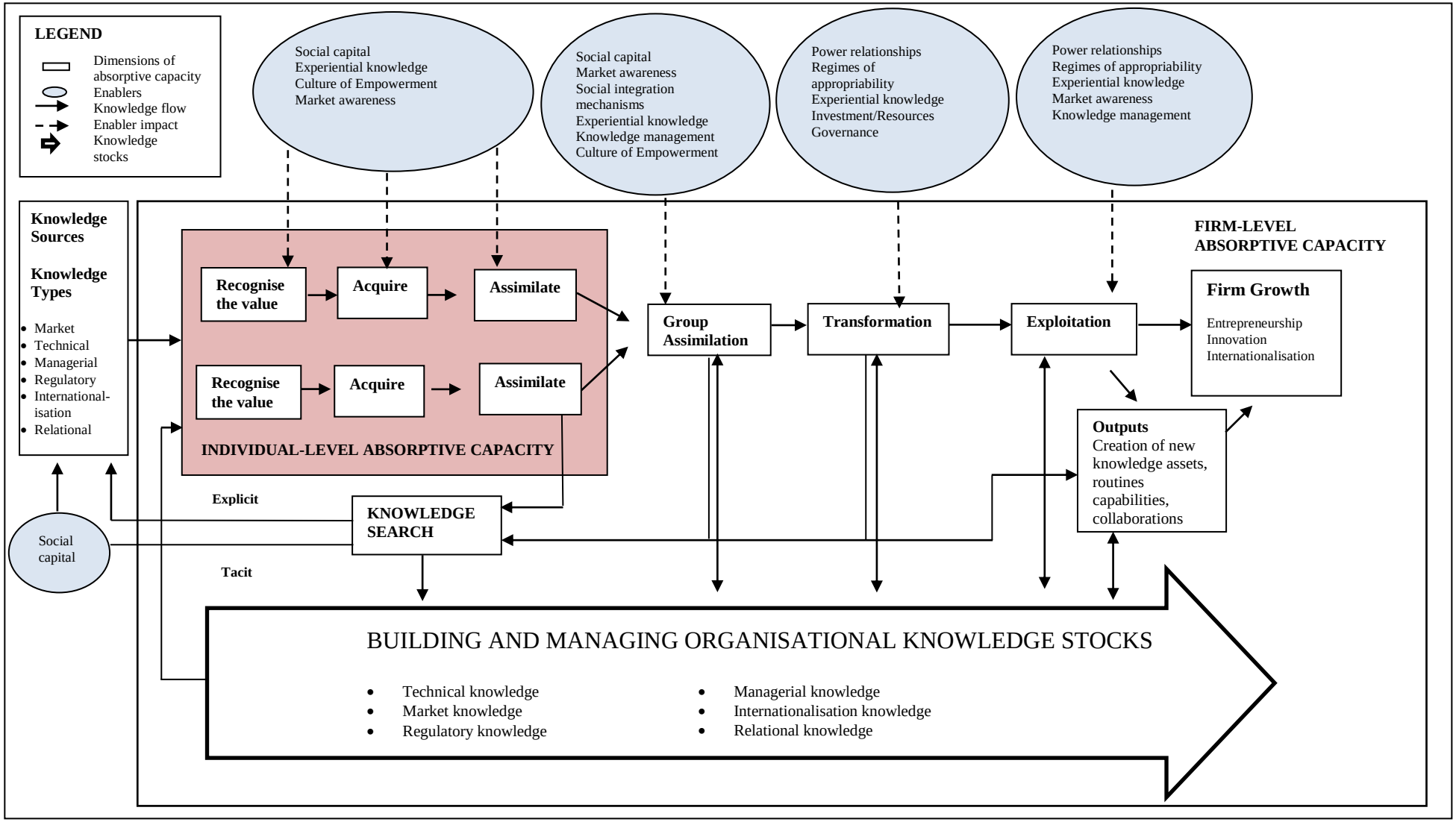
- This model acknowledges that ACAP is a multi-level construct, which bridges individual- and firm-level ACAP. It highlights that assimilation occurs at both levels, explains the interactions between the two elements, while highlighting how firms can harness and maximise the value from individual ACAP, through establishing an appropriate organisational culture.
- The individual component of ACAP comprises of three elements: recognising the value, acquisition and assimilation of knowledge.
- This model highlights the importance of knowledge flow within the firm, providing insights into how the elements of the ACAP process work to build the firm's stock of knowledge, and emphasising the reciprocal relationship between the development of knowledge stocks and the development of ACAP.
- This model acknowledges that the ACAP of the firm is dependent on the firm's ability to establish and maintain relationships with its external constituents in order to access new external knowledge. In addition to the role of social capital in knowledge acquisition, the model also draws attention to the role of social capital in the assimilation of knowledge.
- The addition of feedback loops that demonstrates that the ACAP process is a cumulative, iterative and cyclical process which adds to the firm's stock of knowledge over time, and often needs a number of iterations of particular dimensions over time to reach a commercial exploitation.
- The leverage of knowledge through the ACAP process transcends functional boundaries within the firm and is immersed in the context of the key integrated drivers of growth within the firm and the industry environment in which it operates.
- The leverage of knowledge requires multiple enablers to operate synergistically at each dimension of ACAP to enhance the firm's ability to resolve growth challenges.

8.4 Dimensions of the reconfigured process model of ACAP

8.4.1 Individual-level ACAP

The findings of this study highlight that individuals are responsible for the acquisition of external knowledge, which is consistent with Cohen and Levinthal's (1990:131) view that "an organisation's ACAP will depend on the ACAP of its individual members. Drawing on the human capital literature, individual ACAP is a function of the individual staff members' stock of knowledge as a result of their experience (Becker, 1964). The findings of this study highlight that in HTNVs, the task of acquiring the external knowledge required by the firm is often on the CEO and a few other key individuals that act as

Figure 8.1 A process model of absorptive capacity



Source: Developed by the author from Zahra & George (2002b) based on empirical evidence in this study

gatekeepers, and their ability to assimilate that knowledge and understand its implications may be limited to their personal knowledge and experience. This concurs with Shane (2003:45) who states that "the process of opportunity discovery is cognitive and cannot be a collective act", which places great importance on the individuals who acquire external knowledge and their individual ACAP (i.e. their ability interpret that information) to recognise entrepreneurial opportunities. This study finds that in the main, R&D staff tend to acquire technical knowledge and business development staff tend to gather market knowledge, concurring with the view that entrepreneurs discover opportunities relating to their knowledge and experience (Venkataraman, 1997). Individual ACAP can then be enhanced by further exposure to knowledge, training and learning by doing (experience).

This study finds that building relationships with key actors is an enabler of individual ACAP in both the knowledge search and in the interpretation of that knowledge. Individual ACAP is path dependent (Cohen and Levinthal, 1990; Lane et al., 2006; Van den Bosch et al., 1999) due to the cumulative nature of knowledge. A further discussion of prior experience and links as enablers follows in section 8.5. This study finds that HTNVs invest in new human capital to fill gaps in the firm's ability to leverage knowledge. Furthermore, there is evidence that HTNVs recruit new board members to overcome the limitations of the human capital and social capital of the founding team, which concurs with the findings of Colombo and Grilli (2009) and Fernhaber and McDougall-Covin (2009).

The individual component of ACAP comprises three elements: recognising the value, acquisition and assimilation of knowledge. There is a debate between entrepreneurship researchers who state that opportunity recognition is done by individuals and others such as innovation researchers who state that innovation is a social act. In developing this model, and highlighting that assimilation of knowledge occurs at both levels, this study makes a contribution to knowledge demonstrating how both views can be accommodated.

- *Recognising the value and acquisition of knowledge*

This study finds that in the main, certain individuals in firms have the role of monitoring the environment. However in a number of firms, all employees are empowered and encouraged to scan the environment for suitable external knowledge. In investigating the diversity of exposure of sample firms to external knowledge, this study found that

individuals used multiple sources of knowledge from published explicit knowledge to highly tacit knowledge which could only be accessed through building relationships. This mirrors the notion of 'active listening' posited by Liao et al. (2003:67), which suggests that firms should scan the environment frequently and broadly, and that it should not just be isolated individuals, that it should be the role of all departments. Although intuition occurs at individual level (Sun and Anderson, 2010:143), but there is influence by the group in interpreting the knowledge acquired. This study shows that when individual have a strong sense of the corporate vision and the needs of the firm, and empowered through the culture of the firm, they can search for external knowledge more effectively from the perspective of the organisational context.

- *Individual-level assimilation of knowledge*

Assimilation is the ability to analyse, interpret and understand external knowledge. Individuals recognise the value of knowledge, acquire it and assimilate it at an individual level. This involves the combination of one of more types of knowledge, which can be interpreted or assimilated by combining it with the individual's own stock of knowledge. This mirrors the description of the opportunity recognition process in entrepreneurship literature (e.g., Shane, 2000; Marvel & Lumpkin, 2007), although ACAP is not mentioned in this stream of literature. There are also parallels between the findings of this study and the discussion of the relationship between ACAP and exploratory learning in a recent paper by Sun and Anderson (2010:143) which suggests that the outcome of exploratory learning being dependent on the intuition of individuals. Although there is a view that external knowledge is better assimilated by firms at group level (e.g., Nonaka & Takeuchi, 1995), it is clear from this study that individuals have to make an initial interpretation of the meaning of the external knowledge they have acquired in order to make a decision on whether to disseminate it or not.

- *Harnessing individual-level ACAP*

Individuals build their individual ACAP by being open to learning from experience and by an active open search for knowledge. It is of great benefit to the firm if individuals apply their knowledge and experience to assimilating external knowledge before they bring it to the rest of the firm. Cohen and Levinthal (1990) noted that the firm's ACAP depends on "the individuals who stand at the interface of either the firm and the external environment

or at the interface between subunits within the firm". However, Lane et al. (2006) suggest that the ACAP research community has since ignored the contribution of the individual to corporate ACAP. This study addresses this by highlighting how the firm can effectively harness the ACAP of individuals.

This study also highlights the benefits of employees being empowered to find solutions to issues, in order to bring new product development suggestions, or simply to bring new knowledge which they have recognised to be of value to the wider company and disseminate it to the relevant team. (See example from case E on page 286.) Furthermore, the findings of this study highlight that an organisational culture which encourage this behaviour in employees greatly enhances the ACAP of the firm. This echoes the views of Todorova & Durisin (2007), that individuals who have recognised the value of knowledge need a mechanism for bringing that to the attention of colleagues and they need to have the power to legitimise their contribution. This is consistent with Spender's (1996b:74) view that collective knowledge is a reflection of the social aspects of the individual's consciousness and the firm exists to harness the creative properties of their members.

The findings of this study suggest that the organisation only benefits from the individual ACAP if that individual is encouraged and empowered to search for new knowledge to resolve growth challenges. As individual-level ACAP is dependent on that individual's education, training, experience and links, they can only recognise the value, acquire and assimilate knowledge linked to their own knowledge stocks. The holistic approach to key integrated entrepreneurial processes taken by this study has identified the complex combination of knowledge required to resolve growth challenges. Therefore understanding the challenges being faced by the firm can enhance the knowledge search and the likelihood of appropriate solutions being found in the external environment by individuals. Furthermore, these individuals, having gone through a process of recognising the potential relevance and value of external knowledge and then having acquired and assimilated it, must be encouraged to disseminate that knowledge to appropriate parts of the firm in a way that can be understood by colleagues. Key individuals that act as gatekeepers in the organisation should focus their dissemination activity on the knowledge needs of their colleagues using appropriate social integration mechanisms. Another similar view is Schmidt (2005) that suggests that some types of knowledge (e.g. scientific knowledge)

need to be translated before they are disseminated. Enablers are further discussed in section 8.6.

This study finds that the relationship between individual and group assimilation of knowledge is cyclical and reciprocal. The individual takes the newly acquired knowledge to the group and following discussion with colleagues may search for additional knowledge. The process model of ACAP proposed echoes a proposition by Sun and Anderson (2010:143) that the assimilation dimension of ACAP is a learning capability involving a cyclical process of intuition and interpretation and spanning individual and group level.

Following the above discussion, a further three propositions relating to individual-level ACAP can be made:

Text Box 8.5

Proposition 3.1:	The individual-level component of ACAP comprises of three elements: recognising the value, acquisition and assimilation of knowledge.
Proposition 3.2:	Individual level ACAP is enabled by a combination of social capital, experiential knowledge, a culture of empowerment, an active search for knowledge and market awareness.
Proposition 3.3:	The relationship between individual-level ACAP and firm-level ACAP is cyclical and reciprocal, and dependent on effective knowledge flow between individuals and other parts of the firm, to enable group assimilation to occur.

8.4.2 Firm-level ACAP

The findings from this study suggest that the dimensions of the ACAP process that occur at firm level are group assimilation, transformation and exploitation. The findings demonstrate that these dimensions of the ACAP process contribute to the growth of the knowledge stocks held within the firm. Drawing on the work of DeCarolis and Deeds (1999) who argue that organisational knowledge is comprised of knowledge stocks and knowledge flows, this model emphasises the importance of building and managing knowledge stocks through effective dissemination of knowledge. Furthermore, due to the reciprocal relationship between individual ACAP and the overall enhanced ACAP of the

firm, effective communication and codifying of knowledge enables the firm to benefit from the acquisition of knowledge by individuals. This concurs with Zahra and George's (2002b) discussion of the role of social integration mechanisms.

Firm-level ACAP is not uniform throughout the firm. In larger firms where there are more distinct departments, there will be difference in the ACAP of these teams. This study finds that the ability of a group to leverage knowledge depends on the individual ACAP of team members but also their experience of working together and the routines they employ for knowledge search, knowledge flow between individuals, and the knowledge management processes within the firm. This finding concurs with Daghfous (2004) who notes that the firm-level ACAP is not simply the sum of individual ACAP held by the human capital of the firm.

- *Group assimilation*

This study finds that, depending on the size of the firm, group assimilation of knowledge can occur at management team level, board level or within project teams (For examples, see Figures 6.1-6.8 and 7.4). The evidence found suggests that group assimilation is a mechanism for firms to make the best use of the cognitive schemas of individual members. This component of the process model acknowledges that although it is widely recognised that learning starts with individuals (Cohen & Levinthal, 1990; Argyris, 2004), and group learning is a social process (Nonaka & Takeuchi, 1995). Given the complexity of the challenges faced by HTNVs as they develop and launch products and services in global markets, it is not surprising that firms in this study can be seen to acquire and interpret a considerable amount of diverse knowledge (in 6 categories) which impact on the firm's ability to resolve growth challenges. This study has shown that as a firm grows and increases the depth of its management team, the calibre of interpretation of what knowledge means for the firm increases as individuals with very different experience and knowledge bring different external knowledge into the group assimilation space.

Furthermore, this study finds that as the firm transitions through a growth challenge, if it effectively communicates its goal and issues to be resolved across the organisation, appropriate staff can contribute their skills, experience and connections to finding a resolution. The findings of this study are consistent with research on entrepreneurial teams

(e.g., Ucbasaran et al., 2003; Chowdhury, 2005; Amason et al., 2006; Shrader & Siegel, 2007), suggesting that heterogeneity of team experience improves firm performance (Ensley et al., 1998; Ensley & Amason, 1999), and the better teams members know each other, share a common vision (Ensley et al., 2002), are aware of their diverse capabilities and trust each other, the more effective the team is are at leveraging/exploiting knowledge. Sun and Anderson (2010) advise that firms must strive to insulate the assimilation process from assumptions of individuals that may hinder the group making novel connections between different elements of knowledge and the creation of opportunities.

- *Transformation*

Transformation refers to the ability to derive new insights from the combination of existing and new acquired knowledge (Zahra & George, 2002b; Todorova & Durisin, 2007). The evidence of the transformative capability within the HTNVs in this study are decisions made following assimilation of external knowledge, which have led to the development of knowledge assets and capabilities within the firm that have contributed to the resolution of growth challenges. The combination of knowledge to create new knowledge is very evident from the findings of this study, as case firms can be seen to take a significant amount of market knowledge from various sources in the environment, and combine that with the internal stocks of knowledge.

During the transformation process, companies draw new insights from that combination of knowledge which creates new knowledge. For example, Case I, wishing to evaluate options for taking its lead product to market, combined knowledge it has assimilated about the regulatory and legislative environment in particular markets, an estimation of the likely time and cost of achieving regulatory approval, along with the likely return on investment, to enable decision making about the first market to enter. The firm then evaluates knowledge about potential channels into that market, taking into consideration its current available resources. The combination of this knowledge facilitates the creation of new knowledge which enables a decision to be made about a preferred first international market and a route to market in that geography. Experiential knowledge can be seen to have a major role in enabling transformation to occur with confidence. Case B combined market knowledge from customers with existing stocks of knowledge, which enabled the firm to

decide to change its strategic direction. In deciding to invest in building capabilities to enable the firm to enter a new market, Case A utilised knowledge from past experience (i.e. firm's stocks of knowledge), new external knowledge assimilated from a number cycles of acquisition and assimilation, and from internal monitoring (see Chapter 6). These findings are consistent with the findings of Kogut and Zander (1992) who, although not looking at ACAP, suggested that organisational knowledge advances through combinations of existing knowledge with new knowledge.

This study finds that transformation of the knowledge requires a willingness to act upon knowledge that has been assimilated, which is consistent with the view of Liao et al. (2003), who saw transformation as the key step that makes the firm not just a passive reactor to the environment, but attempts to change constraints and manoeuvre the firm into favourable positions. While assimilation simply adds new knowledge to the existing knowledge base, transformation enables a new shared understanding as the way forward regarding a particular issue, which enables strategic decision making. This dimension of ACAP mirrors King's (2008) idea of 'Utilization', where elaboration involves the addition of different interpretations, infusion (the development of underlying issues) and thoroughness (the addition of multiple understandings by different individuals). This is also consistent with the recent Sun and Anderson (2010) model that links ACAP to organisational learning, which highlights the integration of knowledge at the transformation step.

This study finds that transformation occurs among a team with management responsibility, and the level of seniority of decision-making depends on the significance of the growth challenge being considered, implications of decisions on the firm including the level of investment required to implement it. Therefore, transformation is enabled by the empowerment of teams to make decisions. This study has shown that as a firm grows and increased the depth of its management team, the calibre of the combinative capability, option generation and decision-making increases as individuals with very different experience. This study shows that ACAP, and transformation in particular, is a key to the responsiveness of HTNVs which is consistent with the views of Liao et al. (2003) on the impact of ACAP on SMEs' ability to adapt to environmental change. This study finds that time invested in the transformation of knowledge into a particular opportunity that the firm

can exploit is dependent on the management experience and capability within the firm and regimes of appropriability in the market environment. Ideas can be seen to be 'parked' if it is felt they are not suitable to take forward at a particular time. Sun and Anderson (2010:144) suggest that this step needs an ambidextrous style of leadership that can encompass transactional and transformational styles of leadership in order to evaluate opportunities and threats while maintaining day to day business activity.

Following the above discussion, a further proposition may be made:

Text Box 8.6

Proposition 4:	The transformation of knowledge occurs in decision making teams and is enabled by the culture and governance of HTNVs that empower teams to make decisions based on new insights derived from combining knowledge.

As already discussed (section 8.3), the outcome of the transformation process is often the realisation that the firm needs further knowledge in order to make a strategic decision. A thorough understanding of organisational vision and goals enables individuals to search for the additional knowledge that could help the firm achieve their goals or counter potential threats in the environment. This reinforces that the ACAP process is iterative, and cyclical in nature, as the firm builds the knowledge stocks it needs to make decisions that enable the firm to move to the next stage of growth. This study finds that transformation step also includes the understanding of what more formal structures may have to be put in place in order that the firm can benefit from existing links. The formalising of relationships to create an efficient mechanism for knowledge transfer and extracting value for the knowledge assets of the firm is an outcome of the process, which is usually required in order for exploitation to occur.

This study would suggest that there is always a transformation step, albeit at an appropriate level of decision making for the complexity, risk and cost of the project. This conflicts with Todorova and Durisin (2007), who argue that not all knowledge requires to be transformed in order to be exploited. They suggest that assimilation and transformation cannot be separated as the former deals with incremental learning and the latter deals with more radical learning. This study uses the Zahra and George (2002b) definition of

assimilation, which more generally covers interpretation and understanding of both types of learning.

- *Exploitation*

Exploitation involves putting the external knowledge that has been acquired, assimilated and transformed knowledge into operation (Zahra & George, 2002b). Exploitation of external knowledge is evident in all cases within this study, although there is seldom an immediate growth outcome as a result of a single iteration of the ACAP process. HTNVs in this study demonstrate the exploitation of knowledge in the resolution of growth challenges, ranging from the development of new products and services, the development of capabilities, and the development of new knowledge assets (e.g., patented innovation or clinical trials data), and new organisational forms. However, this study also suggests that the most common outcome of a cycle through the ACAP process is the recognition that further external knowledge is required to enable a decision to be made, or that a stock of knowledge must be developed to capitalise on an opportunity. Therefore, a key finding from this study as outlined in 8.3.1 is that the ACAP process is an iterative and cumulative knowledge process within the firm, building stocks of knowledge at each cycle. In previous studies of ACAP, there has been a focus on measurable outputs of the ACAP process, at the expense of less concrete outputs, which may be of more importance to the growth of the firm in the long run (Lane et al., 2006). Therefore in highlighting the stocks of knowledge that are accumulated as an outcome of the process (see section 8.4.3), this study contributes to the understanding of ACAP. The combined stocks of knowledge add value to the firm and can be utilised in the future. This is especially important for HTNVs that are founded in order to create value from knowledge assets. Furthermore, although building stocks of knowledge is important for HTNVs, of equal importance however is effectively management of knowledge assets, which enables the firm to make a return on the investment it has made.

Exploitation reflects the ability of the firm to achieve a commercial return and new competencies such as sales and marketing capability may have to be created in order for that to occur. For HTNVs that are part of a complex value chain, the commercial exploitation is realised by a downstream partner or by employing a distributor in the

chosen market. This study finds that for exploitation to occur, links that have been made earlier in the process may require to be formalised to a structure that is suitable for formal knowledge transfer and a commercial outcome (see table 7.13). This is consistent with Spender (1996a), who suggests that new organisational forms are the outcome of the processes which exploit knowledge. Furthermore, as HTNVs within the life science industry are often small players with little influence on downstream outcomes, the successful exploitation of knowledge assets may be dependent on the selection of appropriate downstream partners. This highlights another key role for social capital in the leverage of knowledge in building relationships with future commercial partners.

The speed and scale of exploitation of external knowledge by the firm is governed by a combination of internal and external factors. In addition to the complexity of the opportunity that has been discovered, external factors such as the state of the market, the availability of finance, and regimes of appropriability such as the lead time in the given market, all have an impact on the speed of exploitation of knowledge. Internal enablers of exploitation, such as social capital, prior experience, knowledge management and market awareness are discussed further in section 8.5 along with their impact on the temporality of exploitation of knowledge in section 8.6.

8.4.3 Knowledge outputs of the ACAP process: building knowledge stocks

This study finds that the leverage of knowledge through the ACAP process interacts with both individual and firm knowledge stocks at every dimension of the process. This is consistent with the knowledge-based view of the firm which depicts the firm as a repository of knowledge and competencies (Grant, 1996). Knowledge stocks refer to the amount of knowledge elements a firm has accumulated over time (Dierickx & Cool, 1989:1509) or in other words the firm's intellectual assets. This study also supports Lane et al. (2006), who highlighted the knowledge outputs in their model of the ACAP process.

When an individual within the firm has a knowledge requirement, the firm's knowledge stock is likely to be the first port of call in the knowledge search. This may be done by examining the firms stocks of codified knowledge or by talking to colleagues. When individuals recognise the potential value of external knowledge, they may compare this

new knowledge with their existing individual knowledge stock and with the firm's stock of knowledge in the firms, to assist with individual assimilation. Individuals that are familiar with the firm's stocks of knowledge may do this subconsciously.

This study finds that dissemination of knowledge to colleagues (group assimilation) is the first point where the knowledge is added to the firm's knowledge stocks. As further knowledge is sought and assimilated through the ACAP process to enhance the firm's ability to make a decision, the stock of knowledge within the firm increases. This is consistent with Cohen and Levinthal (1990:131) view that the "intensity of effort is critical". In order to be able to leverage benefit from new knowledge, the firm must first spend time evaluating what it means for the firm, engaging with existing knowledge stocks. The investment in the creation of particular knowledge assets, capabilities or collaborations to exploit a market opportunity, again adds to the knowledge stocks of the firm, which in turn enhances the firm's ACAP.

- *Building organisational stocks of knowledge through the ACAP process*

This process model of ACAP acknowledges the interconnectedness of knowledge processes within the firm. In particular, this study highlights that the creation and management of the firm's knowledge stocks runs through all other dimensions of the ACAP process, and the resulting process model enhances our understanding of how the elements of individual- and firm-level ACAP interact with the firm's stocks of knowledge. This study finds that the ACAP process is similar for firms at different stages of maturity although, the firm's ability to assimilate knowledge is dependent on its accumulated stocks of knowledge. This study finds that the firm builds stocks of knowledge in 6 key areas: 1) technical, 2) market, 3) regulatory, 4) managerial, 5) internationalisation and 6) relational. These have been previously described in section 7.7.1.

This study finds that particular stocks of knowledge are held in the human capital of the firm, both by individuals and in special project teams such as new product development or operations teams. It is often intangible and not recorded on the firm's balance sheet (Lin & Wu, 2010:583), but clearly has the potential to generate growth in the firm. This study has found that firms increase their stock of knowledge by recruiting new staff that have knowledge and expertise in the area where the firm requires more knowledge. When the

requirement is short-term, this study has found that this has been done using consultants. Where a key element of knowledge is missing from the knowledge stocks of HTNVs, this study finds that the recruitment of highly experienced new staff can be substituted by bringing in new, experienced board members who can inject the required knowledge. This study has found significant evidence that suggests that HTNVs use their Board of Directors as a means to enhance their ACAP. Either board members themselves or their social capital can be a means of bringing in particularly experienced individuals to assist with the assimilation of particular knowledge. Firms in this study have a variety of ways of incorporating that new external knowledge into the firm's wider memory, which range from establishing standard operating procedures, training of project teams by an experienced individual or consultant, intranet systems for key projects, and meeting minutes.

Following the discussion thus far on the knowledge outputs of the ACAP process, a further two propositions can be made:

Text Box 8.7

Proposition 5.1:	HTNVs that build internal knowledge stocks have an enhanced ACAP.
Proposition 5.2:	HTNVs increase the stock of knowledge and ACAP by the recruitment of new human capital including new staff and board members.

8.5 Enablers of leverage of knowledge by HTNVs through the ACAP process

Having established the importance of being able to successfully combine different types of knowledge to find solutions to the firm's growth challenges, identifying the factors which enable the leverage of knowledge through the ACAP process is key to advancing an effective process model of ACAP and providing practical guidance to practitioners within HTNVs.

Chapter 7 has highlighted a number of enablers of the leverage of knowledge, and table 7.14 highlights the key enablers for each dimension of the ACAP process. These are summarised in table 8.1.

Table 8.1 A summary of enablers of the leverage of knowledge by ACAP dimension

Individual-level ACAP	Firm-level ACAP		
Recognising the value, acquisition and assimilation	Group Assimilation	Transformation	Exploitation
Prior experiential knowledge Social capital Culture of empowerment Market awareness	Prior experiential knowledge Social integration mechanisms Culture of empowerment Market awareness	Prior experiential knowledge Power relationships Regimes of appropriability Investment of resources Governance Market awareness Culture of empowerment	Prior experiential knowledge Partners Power relationships Regimes of appropriability Market awareness Knowledge management

Source: developed from cross case analysis

The process model of ACAP in Figure 8.1 illustrates the enablers of each stage of the process. Some enablers of the exploitation dimension such as the regimes of appropriability and power relationships, impact the commercial exploitation of knowledge, but are outwith the direct control of the firm due to the nature of the industry. Therefore this discussion focuses on the enablers that the firm can control internally and these are summarised in a variance model in Figure 8.2. This model illustrates that the presence of each of these enablers have a positive effect on the firm's ability to leverage knowledge. However, a new insight that this study provides is the need for all of these enablers to be present for maximum efficiency in the leverage of knowledge. Evidence drawn for analysis of enablers for each of the key growth challenges highlights the presence of multiple enablers, with no individual enabler being identified as being able to enhance the speed of

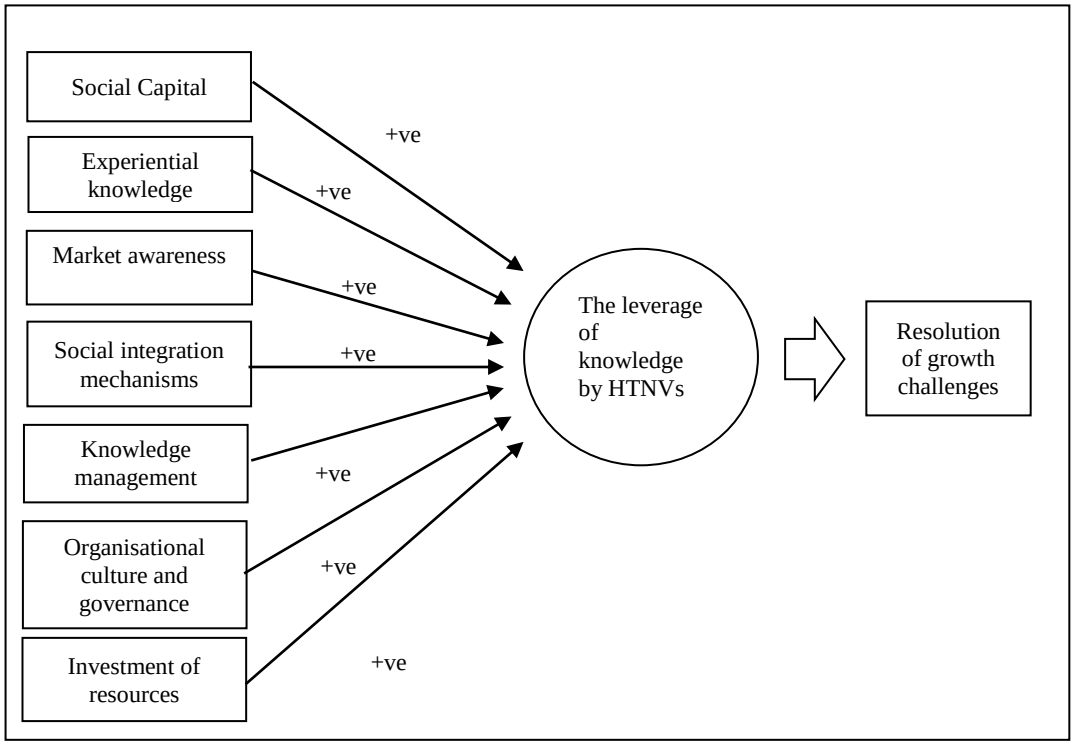
knowledge leverage in isolation. For example, firms may have experienced individuals with the experience and social capital to access knowledge, but if the firm does not have an effective internal communications mechanism to disseminate that knowledge to the part of the business that could benefit from it, value will not be leveraged from that knowledge.

From the above discussion, a further proposition may be made:

Text Box 8.8

Proposition 6:	HTNVs maximise the leverage of knowledge through the ACAP process when a number of enablers are present and working in synergy.

Figure 8.2 The key internal enablers of the leverage of knowledge by HTNVs



Source: Developed from cross case analysis

This study has found that key internal enablers of the ACAP process are a) social capital, b) experiential knowledge, c) market awareness, d) social integration mechanisms e) management of knowledge stocks, f) organisational culture and governance and g) investment of resources. These enablers are discussed in turn, elaborating on how they impact on the leverage of knowledge. As the sample firms in this study are HTNVs

founded to capitalise on innovation, they tend to have a high R&D intensity, so although investment in R&D is identified as an enabler by Cohen & Levinthal (1990) and Veugelers (1997), it is not discussed by this thesis. With the objective of developing further understanding about enablers of the ACAP process for HTNVs, the enablers have been analysed according the growth challenges being faced by the firms (see Table 8.2). This highlights that social capital is potentially as important as prior experiential knowledge as an enabler for the leverage of knowledge at every growth challenge. Its impact is discussed in the next section.

Table 8.2 Enablers of knowledge leverage according to the growth challenge being faced

Growth challenge	Individual-level ACAP	Firm-level ACAP		
	Recognising the value, acquisition and assimilation	Group Assimilation	Transformation	Exploitation
New product /service development (Innov & E)	Experiential knowledge Social capital Culture of empowerment Market awareness	Experiential knowledge Social integration mechanisms Culture of empowerment Social capital	Experiential knowledge Investment of resources Governance Culture of empowerment	Experiential knowledge Partners/ Customers Power relationships Regimes of appropriability Market awareness Knowledge management
New market development (Innov & E)	Experiential knowledge Social capital Market awareness	Experiential knowledge Social integration mechanisms Culture of empowerment Social capital	Experiential knowledge Investment of resources Governance Market awareness	Experiential knowledge Partners/ Customers Power relationships Regimes of appropriability Market awareness Knowledge management
New international market development (E, Int & Innov)	Experiential knowledge Social capital	Prior experiential knowledge Social capital	Prior experiential knowledge Investment of resources	Partners Market awareness
Collaborations (Innov)	Experiential knowledge Social capital	Prior experiential knowledge Social capital	Prior experiential knowledge Governance Social capital	Partners Customers
New facilities (Innov)	Experiential knowledge Social capital	Prior experiential knowledge Social capital Investment of resources	Experiential knowledge Investment of resources Governance Market awareness	Partners Market awareness Regimes of appropriability
Attaining quality standard/accreditation/regulatory approval (Innov)	Experiential knowledge Social capital	Prior experiential knowledge Social capital	Experiential knowledge Investment of resources Social capital	Social capital Partners Market awareness Customers
Raising finance (E)	Experiential knowledge Social capital	Experiential knowledge	Experiential knowledge	Investors
Sourcing suppliers (Innov)	Experiential knowledge Social capital	Experiential knowledge Social capital	Experiential knowledge	Partners Suppliers
Drivers of small firm growth: Innov= Innovation, Int = Internationalisation, E = Entrepreneurship				

Source: Summarised from table 7.14

8.5.1 Social capital as an enabler of ACAP

A key finding of this study highlights the importance of social capital as an enabler of ACAP, enhancing the ability of HTNVs to leverage knowledge. As HTNVs tend to be small players operating in complex global value chains, managing a portfolio of relationships across the value chain is vital to business development and firm growth. Consistent with Yli-Renko et al. (2001), this study finds evidence to suggest that social capital impacts on the acquisition of external knowledge in terms of both providing access to tacit market knowledge, and due to relationships developed with customers and potential customers, facilitating the recognition of the value of that knowledge. These findings corroborate earlier work of Vinding who suggested that the development of close relationships may contribute to a firm's ACAP because 'such relationships may create and strengthen information channels and 'thicken' knowledge flow, thus increasing the efficiency of the transfer of tacit knowledge'(Vinding, 2006:508). This study also extends the development of social capital theory by defining the types of social capital which impact on the ability of HTNVs to leverage knowledge to resolve growth challenges (summarised in table 7.15). The holistic approach of this study reveals the complexity of the interwoven challenges faced by HTNVs and highlights that HTNVs with a high demand for new external knowledge utilise varying combinations of types of social capital to access the knowledge they need to resolve the complex challenges they are facing. Furthermore, HTNVs also use different types of social capital at each dimension of the ACAP process to leverage knowledge.

In Chapter 3, the review of ACAP literature reveals that although Zahra and George (2002b) include 'new connections' in their table outlining the dimensions of ACAP, social capital has received very little attention from ACAP researchers (apart from Lim, 2009) who states that ACAP is a function of the firm's connectedness, Daghfous (2004) who suggests that ACAP is determined by the strength of relationships with others in networks, and von Hippel's (1988) work on the benefits of relationships with suppliers. Lane et al. (2006) note the importance of relationships in their learning process model of ACAP, but do not develop this aspect further. Todorova and Durisin (2007) expand Zhara and George's (2002b) concept of social integration mechanisms, describing information dissemination within the firm, to include external social networks and suggest that it

impacts on all aspects of ACAP. Overall, the impact of social capital on the ACAP processes of HTNVs has been largely ignored.

Despite the lack of attention of ACAP scholars to the impact of relationships, the notion of social capital having a positive impact on small firm growth is not a new concept. This study has highlighted that for the ACAP process to function, and for firms to leverage external knowledge, channels to access that knowledge must exist. This echoes the findings of Nahapiet and Goshal (1998:250) who argue that "social capital facilitates the development of intellectual capital by affecting the conditions necessary for exchange and combination to occur". Chapter 2 highlights that scholars in the fields of innovation (e.g., Veugelers, 1997), internationalisation (e.g., Coviello, 2006; Coviello & Munro, 1995, 1997; Jones, 1999) and entrepreneurship (e.g., Callon et al., 1997; Lichtenstein & Brush, 2001) recognise the importance of social capital to enable firms to gain access external knowledge that is important for the growth of the firm. As all the firms in this study have a significant proportion of customers in international markets, building links and relationships enables the firm to gain access to geographically distant sources of technical and market knowledge, due to the reduced cognitive distance (Gassmass & Kuepp, 2007) facilitated by the firm's social capital. This study exemplifies assertions by Teece (2001) and Macpherson et al. (2004) that knowledge networks are integral to the ability of HTNVs to renew their capabilities.

This study in suggesting a reciprocal benefit between ACAP and social capital concurs with a more recent study by Torré (2008) who suggested that firms with ACAP were more likely to develop external linkages than firms with lower ACAP. This study has also highlighted the importance of specialist technical networks and special interest groups to keep abreast of technical and market developments. These niche communities develop a shared language, which aids the recognition of valuable knowledge and also facilitates interpretation of what it means for the company. It is not surprising that since knowledge is socially constructed, HTNVs in this study add to their stocks of knowledge through complex social interaction with external organisations.

Social capital as an enabler of knowledge acquisition

The findings of this study reveal that in line with network theory, firms gain access to and mobilise resources through their social capital. There is evidence from this study that social capital is used as a tool for monitoring the external environment for a wide range of knowledge which mirrors the findings of Granovetter (1982), Freeman (1991) and Hansen et al. (1999). This study has already highlighted that knowledge is acquired by individuals, emphasising the role of the gatekeeper in sourcing external knowledge for the firm. Therefore building social capital is a vital enabler to individual-level ACAP, facilitating sourcing of tacit knowledge. This study therefore reinforces the views of Coleman (1988) and Nahapiet and Goshal (1998:252) that social capital creates information channels that both reduce the amount of time and investment required to gather knowledge. This is particularly true of two firms who used their social capital to access technical knowledge before it was publicly available. Their ability to access and leverage this knowledge through the ACAP process and develop an appropriate product or service is crucial to commercial success. The study is consistent with early research on social capital. Granovetter (1973) proposed that weak relations (social capital) serve as bridges to other social groupings holding information and resources unavailable within one's direct social circle.

This study also highlights the importance of the social capital of board members and investors to the ACAP of HTNVs. These findings add weight to the view of Fernhaber and McDougall-Covin (2009), who suggest that social capital of board members, and in particular venture capitalist investors, can enhance the limited social capital of inexperienced managers of HTNVs. Furthermore, this study finds that the complex value chain of which HTNVs in the life science industry are part means that they have to have the ability to build social capital both upstream and downstream to maximise opportunities for growth.

Social capital as an enabler of assimilation

The findings from this study provide strong support for the proposition that social capital assists with interpretation of external knowledge and therefore enhances assimilation by HTNVs. As a result, effective networks and relationships increase the speed of acquisition and assimilation and enable the firm to respond faster to market opportunities and threats.

Social capital or indirect ties can serve as a screening device (Leonard-Barton, 1984), where each relationship can serve as an additional information filter, absorbing, sifting, classifying complementary knowledge in a manner that goes beyond the information processing capabilities of a single firm (Salman & Saives, 2005). Although Yli-Renko et al. (2001) found a mediating role of social capital on acquisition and exploitation of knowledge, they did not examine the assimilation dimension, so this study makes a contribution to the deeper understanding the full impact of social capital on the firm's ACAP.

Social capital as an indirect enabler of transformation and exploitation

Crucially, although social capital can be seen to have an impact on the acquisition and assimilation dimension of ACAP, partners and collaborations can been seen to be of importance to the timely exploitation of external knowledge in order to quickly address particular growth challenges. The partnerships and collaborations that do facilitate the commercial outcomes of leveraging external knowledge originated in these relationships and therefore the building of appropriate social capital in earlier stages is important. This evidence suggest that ACAP process has a role to play in transforming links and connections into appropriate more formal connections that can provide the firm with a growth outcome.

These findings reinforce some of the earliest work on ACAP. Cohen and Levinthal (1990:544) argue that in order to grasp what the sources of a firm's ACAP, one should concentrate on "the way the communications between the firm and the external environment." However as the existing body of literature has concentrated solely on the acquisition of knowledge through relationships, this thesis takes the field's understanding further by evaluating the contribution of social on assimilation and exploitation dimensions of the leverage of knowledge through the ACAP process.

Therefore, drawing on Cohen and Levinthal's (1989:569) seminal work where they propose that the cost of acquiring external knowledge is small at the time of learning because the firm has already invested in the ability "to identify, assimilate and exploit knowledge from the environment – what we call a firm's 'learning' or 'absorptive capacity'", this study proposes that the cost of acquiring knowledge may be small at the

time of learning due to the prior investment made in developing appropriate social capital. The findings from this study suggest that prior investment in building relationships and networks can make a significant impact on the ACAP of the firm. Therefore, this study proposes that the development of social capital is an enabler and antecedent to ACAP, which has the greatest impact on acquisition and assimilation dimensions of the ACAP process. These findings are consistent with Cohen and Levinthal (1990:132) who recognised the importance of external relationships in the development of ACAP. However, due to the cost implications of developing relationships and networks, especially across a complex value chain, and this study concurs with Yli-Renko et al. (2001) that finding an optimum level of social capital is a challenge for HTNVs.

Taken together, the aforementioned observations relating to social capital lead to the following propositions:

Text Box 8.9

Proposition 7.1:	Social capital is an enabler of individual-level ACAP and an antecedent to the development of firm-level ACAP.
Proposition 7.2:	HTNVs that invest in the development their social capital alongside other enablers of ACAP have enhanced ability to acquire and assimilate knowledge.
Proposition 7.3:	HTNVs that build appropriate social capital can quickly and cost-effectively acquire knowledge to resolve challenges at critical events due to prior investment made in developing the social capital that enhance the firm's ACAP.
Proposition 7.4:	Social capital enables the acquisition and assimilation or knowledge and is an antecedent to the collaborations and partnerships which enable the exploitation of knowledge.

- *The social capital of Board Members*

A particularly significant finding is that the Chairman and Board members of HTNVs are able to draw on their relationships to help the firm quickly acquire and assimilate the external knowledge it requires to resolve the particular growth challenges it is facing. Although the sample firms were selected to achieve a spread of maturity, they are all HTNVs in the process of transitioning between start up and more professional management

phase, so the introduction of new board members is particularly pertinent to the growth of these ventures.

The Board can enrich their firm's knowledge base by connecting them to external sources, enhancing their ACAP. These findings would suggest that board member links could substitute for the development of certain of stocks of knowledge within the firm. These findings complement the suggestions of Zahra et al. (2009:257), whose study on threshold firms highlighted the arrival of additional board members as a means to "creatively offset some of the limitations of their resources (especially knowledge) and use their directors as a means of gaining knowledge that stimulates innovation" (2009:257). Experienced non-executive directors who introduce and share their knowledge, diverse experiences, and connections with managers and other directors can enrich the threshold firms' ACAP.

These findings fit with the literature (e.g., Daily & Dalton, 1992) on positive impact of board members on the performance of young firms. This is particularly important for young HTNVs where the first challenge is often survival prior to growth. Younger companies in this study highlighted the help provided in efficient running of the company where the management team did not have these skills, although highly educated. Links of the chairman was found to assist with the recruitment of expertise in financial management which assists the firm operate more efficiently as it grows. Zahra et al. (2009:257) highlights the importance of directors in "protection and even increasing shareholder wealth". This research is also consistent with the view of Sirmon et al. (2007) that boards can guide the development of organisational strategies for obtaining, configuring and bundling and leveraging knowledge based resources. These findings are also consistent with Hillman et al. (2000) and George et al. (2001) who note the importance of board members connections to the external environment.

Venture Capital (VC) representatives on the board do more than just monitor their investment. Firms in this study have described how experiences life science VCs used their connections to help the firm with regulatory issues or to recommend appropriate distributors in particular markets. These findings also concur with the view of Powell et al. (2002:294) who posit that "experienced VCs use their abundant contacts to provide referrals to specialised sources of expertise, such as patent lawyers and consultants". The

findings of this study demonstrate the impact of links of board members is much more than just links to professional services. The board adds credibility and legitimacy and in doing so opens up doors to access knowledge from certain external resources and networks.

The coaching role of VCs for the management teams of small firms is well documented in the areas of strategic planning, marketing, finance, accounting and human resource management. However, more recently, the benefits of the social capital of VCs have been highlighted (Fernhaber & McDougall-Covin, 2009). Colombo and Grilli (2009:615) also note that "portfolio companies may take advantage of the network of social contacts of VC investors with potential customers, suppliers and alliance partners." The findings of this study also suggest that there is significant benefit to HTNVs in seeking investment from industry-specific VCs who have the experience and connections that can assist the firm in achieving its ambitions.

Text Box 8.10

Proposition 7.5:	HTNVs that utilise the social capital of Board members have enhanced ACAP, gaining timely access to knowledge, which assists in the resolution of growth challenges at critical events.

The findings of this study reinforces the need for active well-connected boards and would suggest that management teams of HTNVs should play an active role in maximising the value from board members, by utilising their links and connections. Drawing on recent work by Zahra et al. (2009) that suggests that effective boards substitute for low ACAP and similarly, high ACAP in the management team means that it is less dependent on board members, management teams with an understanding of their knowledge and social capital weaknesses or shortcomings, can recruit board members that can fill gaps in their knowledge.

8.5.2 Experiential knowledge as an enabler of ACAP

This study has found that experiential knowledge within the firm is a key enabler of the ACAP process, impacting on all dimensions, from enhancing individuals' ability to assess the value of particular knowledge, combining it with internal knowledge and interpreting what it means for the firm, to the realisation of new opportunities which can be exploited. This is consistent with Cohen and Levinthal (1990:544) who recognised its importance in their seminal article, highlighting that ACAP is dependent on "the nature of the know-how and experience within the organisation". Prior experiential knowledge is heavily weighted by entrepreneurship literature as being the source of human capital. However, ACAP literature has not progressed understanding of the impact of prior experience on the ACAP process.

The model of the ACAP process advanced by this thesis suggests that prior experiential knowledge is a key enabler of all dimensions of ACAP. However, different types of experience are of value at the different dimensions of the ACAP process. All cases within this study demonstrate evidence that experiential knowledge of the industry enables HTNVs to assess the value of technical knowledge such as published scientific and clinical data, and interpret it in combination with other data such as market knowledge to create a prediction of future market demand for a new product. Furthermore although prior technical knowledge is needed to be able to interpret the scientific data, prior market knowledge is also needed to interpret the market opportunity. This is especially challenging where there are no similar products on the market, and the market has to be created. This evaluation can only be done by individuals with significant industry knowledge, and experience of developing and launching other new products with disruptive technology, and an understanding of routes to market within complex value chains. In an industry such as life sciences that is heavily regulated, there is also a need for an understanding of the regulatory environment. Furthermore, a firm will only make a good return on its investment if it has the ability to successfully do deals with partnering organisations. This study finds that the stock of tacit knowledge is developed by individuals over many years and cannot be pinned down to one source. The findings of this study mirror the thoughts of Marvel and Lumpkin (2007) discussing opportunity recognition from an entrepreneurial standpoint, where they refer to four types of prior

knowledge that are important as being 1) ways to service markets, 2) customer problems, 3) markets and 4) technology. It is also evident that the experience of individuals and teams is also key to the organisation's stocks of knowledge.

Experiential knowledge and individual-level ACAP

This study demonstrates that individual's prior knowledge and experience influences both their locus and efficiency of search for new knowledge, finding that the highly educated employees of HTNVs increase the stocks of knowledge of the organisation and in turn enhance the ACAP of the firm. This echoes the findings of Mangematin and Nesta (1999). This study also finds that experiential knowledge assists the creation of social capital, as scientists in HTNVs made connections with scientists with similar interests and expertise in other firms, and that in a number of cases these links led to business for the firm. This is consistent with the work of Rothwell and Dogson (1991) who also found that highly educated employees are more likely to build links with individuals with similar competencies in other organisations. As social capital also enhances the ACAP of the firm, experiential knowledge therefore has a two-fold impact on the ACAP of the firm. However, this study finds that the business development expertise required to assimilate and transform knowledge can be missing from the human capital of young HTNVs. This gap in the ACAP of the firm is plugged through the recruitment of new staff with this knowledge, experience and connections. Training of personnel was also highlighted by a number of respondents as a way of keeping staff at the forefront of scientific advances, and other issues such as quality standards. This is evidence that firms should consider staff training and encouraging them to join special interest groups as a means to enhance the firm's ACAP.

Experiential knowledge and firm-level ACAP

This study finds that the experiential knowledge of an established team is also a powerful enabler of ACAP. A number of the firms in this study (cases A, D, E & I) were founded by entrepreneurial teams that have worked with each other for many years. There is significant evidence that when members of a management team have experience of working together, trust each other and fully understand each other's capabilities and roles in relation to the task in hand, the team performance towards their objectives is high, giving that firm a competitive advantage. Efficient knowledge flows within a team that

works effectively together mean that when faced with a challenge, it is directed at the member of the team is best placed to provide a solution. These findings are consistent with Nelson and Winter's (1982) notion of 'routines' that distinguish the performance of experienced teams. Furthermore, prior experience of fast-growing HTNVs gives a management team a level of confidence and capability in this dynamic environment. Experience of this environment gives the management team the ability to put a structure in place that can accommodate the high growth of the firm and to anticipate and plan for future growth challenges. When it comes to transformation and exploitation dimensions of the ACAP process, prior managerial experience of doing deals such as distribution or collaboration agreements can have more impact on the growth outcomes.

Text Box 8.11

Proposition 8:	HTNVs whose management teams have relevant prior experiential knowledge have enhanced ACAP, with different types of experience being of value at the different dimensions of the process.

8.5.3 Market awareness as an enabler of ACAP

This study has found that being aware of and engaged with the marketplace is of key importance for HTNVs ability to resolve growth challenges. The findings indicate that customers and potential customers are a key source of knowledge for HTNVs (See Table 7.5).

This study highlights that demand-pull HTNVs in the sample appear to be very aware of and connected with their market. However, this study also finds that technology-push HTNVs at the very early stages of drug discovery or product development, which are not yet in a position to have customers, still benefit from having market awareness. Developing an understanding of the potential routes to market, by building links with potential customers of the product or service and intermediary distributors, is key to positioning the product or service at a later date. On the other hand, HTNVs with radical innovations might be well advised to guard against being too customer focused due to the power relationships that large customers can have over smaller suppliers can prevent technological innovation (Todorova & Durisin, 2007: 782). That said, this study has

shown that engagement with the marketplace during product development can yield valuable knowledge that the market demand is changing (case B). Assimilation of this market knowledge enabled the firm to assess the threat to the anticipated market for the product in development and can precipitate a change in strategic direction.

This study highlights that customer views are seen as an important barometer of that service provision. For example, for two medical technology companies (cases F & G) developing diagnostic products, knowledge about customer preferences, market entry modes and distribution channels was crucial. For these cases, the market information gained from both potential customers during market research and customers after the product launch has been very important to further exploitation and the maintenance of a competitive advantage. These findings concur with Shane (2003) who argues that people in customer facing roles such as sales and marketing functions also provide access to market knowledge necessary for opportunity discovery, because they are often the first to learn of customer preferences.

In investigating how HTNVs access market knowledge, this study finds evidence for the key roles of social capital alongside market awareness for the acquisition and assimilation of market knowledge from customers. Operating in niche sub-sectors of the life science industry, with little published data available, access to relevant market knowledge can also be a challenge for HTNVs. This study highlights that building relationships with customers and potential customers is essential to access tacit market knowledge (See table 7.10). This study finds that once trust is developed in the relationship, customers provide significant commercially sensitive information about their current and future activities, which enables the firm to better position their products and services. These findings are consistent with the social capital theory on building trust (Coleman, 1988; Liao & Welsch, 2003) in relationships by providing reliable knowledge, which in turn is reciprocated. HTNVs assimilate this tacit market knowledge, and build a better understanding of industry dynamics and customer requirements.

Market awareness enables HTNVs to leverage other types of knowledge

The findings of this study suggest that awareness of and engagement with their market enables firms to address other knowledge requirements in addition to market knowledge. A

number of the cases in this study provide specialist services to the pharmaceutical industry. These cases highlighted that customers also provide important technical and regulatory knowledge, about their requirements often discussing issues or problems that they face. This enables the firms to design the technical aspects of products and services to the needs of their customers. Furthermore the findings from this study suggest that in order to facilitate the development of products and services that are appropriate to market requirements, HTNVs should be enhancing their ability to leverage tacit market knowledge by building relationships with the market place at an early stage in new product/service development.

It is suggested by this study that in order to acquire and assimilate regulatory knowledge held by customers, firms need to develop market awareness and engage with customers. The life science industry is strictly regulated, but it is a challenge to interpret how regulatory guidelines impact on particular players. Customers provide knowledge about how that regulation impacts on them and as a result, how that in turn will impact on the firm. This study has highlighted that conforming to the regulatory standard is simply the removal of an obvious first barrier to entry to this market. Increased interaction with potential customers and the opening up of additional communications channels between both organisations enabled Case A to understand more fully how they need to adapt the quality assurance processes to create added value for the customer. Creating capabilities that are recognised as providing added value to the customer gives the firm a competitive advantage, which leads to growth. Furthermore, in the cases where the firm provides a service which is a regulatory requirement, feedback from customers regarding discussions that they have had with regulatory authorities provide regulatory knowledge about new safety concerns. The assimilation of this regulatory knowledge, combined with the firm's existing stock of technical, regulatory and market knowledge, enables the firm to understand the need to develop a new test/assay as a potential market opportunity.

Market awareness across the value chain

This study finds that HTNVs in the life science industry are predominantly at the R&D end of a complex global industry value chain. The medical technology firms in the sample are closer to the market than drug discovery and development companies, but both rely on distributors or marketing partners to take the product to consumers and face the challenge

of selecting an appropriate downstream partner. Providers of specialist services to pharmaceutical and biotechnology industry provide direct to the customer that requires the services, but the power to decide on the requirements of the service seldom lie exclusively with the direct customer but reside elsewhere such as with regulatory authorities or with the pharmaceutical company that has outsourced that part of the process to a third party. Therefore, this finding suggests that HTNVs can benefit from a market awareness that extends across the value chain in order to fully understand the market dynamics. The importance of understanding the value chain fits with Newey and Shulman's (2004) conceptualisation of systemic ACAP across multiple firms in an R&D system.

Market awareness enables better marketing communication

The findings of this study suggests that knowledge assets from HTNVs at the upstream end of the value chain can be of significant value to large downstream players, but they may not have the ACAP to recognise their value. This study finds that customers, in addition to discussing their problems and requirements, also can provide the HTNVs knowledge about what they value from them, enabling HTNVs to differentiate their offering and tailoring their marketing communications to demonstrate added value to customers. Where regulatory requirements are standard, safety testing firms differentiate themselves by the added value and quality of service they provide. HTNVs utilise the knowledge they have gained through their market awareness to promote their knowledge assets in a way which makes the knowledge they provide more easily assimilated by their potential customers. This suggests that part of relationship building is considering how HTNVs can be more attuned to address the knowledge requirements of their downstream customers. By considering the ACAP of potential customers, their ability to assimilate knowledge, HTNVs can provide knowledge that is meaningful to them. This addition to the ACAP construct fits with the ideas emerging from Pandza and Holt's (2007:350) research in the nanotechnology sector where they suggest that small firms with emergent technology should develop a "supply-driven transformative capacity."

The findings from this study suggest that having a market focus enables the firm to maximise the outcomes of the ACAP process. While many researchers that have investigated ACAP only looked at R&D function within the firm, this study places ACAP as a capability that transcends functional boundaries.

From the above discussion, the following propositions can be made relating to market awareness:

Text Box 8.12

Proposition 9.1:	The leverage of certain knowledge types is dependent on the orientation of HTNVs towards their markets.
Proposition 9.2:	HTNV that have market awareness across the global value chain are better able to leverage knowledge.
Proposition 9.3:	HTNVs with market awareness are dependent on their social capital to enable the leverage of tacit market knowledge across the value chain.
Proposition 9.4:	HTNVs with market awareness at an early stage of product development are better able to exploit the outputs of the ACAP process by utilising tacit market knowledge to develop products aligned to customer requirements.
Proposition 9.5:	HTNVs with market awareness are better able to exploit the outputs of the ACAP process by utilising tacit market knowledge to enhance marketing communication.

ACAP to date has been seen very much from the point of view of the upstream R&D activity of the firm looking to acquire knowledge. The concept of market orientation (Homburgh et al., 2007) which has developed in the marketing field incorporates many of the elements of ACAP but from a marketing perspective. For example, market orientation as defined by (Kohli & Jaworski, 1990:6) is "the organisation wide generation of market intelligence pertaining to current and future customer needs, dissemination of the intelligence across departments, and organisation-wide responsiveness." Future studies should look at the relationship between ACAP and market orientation.

8.5.4 Social integration mechanisms as an enabler of ACAP

Effective communication within the firm was central to Cohen and Levinthal's (1989) seminal article on ACAP, a concept that Zahra and George (2002b) referred to as social integration mechanisms. More recently, Matusik and Heeley (2005:554) noted that "for absorptive capacity to increase, the ability to route new knowledge to the appropriate

people and areas within the firm are central". The analysis of knowledge flow within the sample firms in this study highlight the importance of ensuring that knowledge is disseminated effectively throughout the organisation. This has also been highlighted as a key part of harnessing the knowledge acquired and assimilated by individuals.

A key element of a firm's successful understanding of the implications of external knowledge involves the effective dissemination of knowledge to the appropriate parts of the business. The findings chapter outlined the knowledge flow within the firm and highlighted the routines by which external knowledge is communicated throughout the firm. Consistent with the work of Heeley (1997), Zahra and George (2002b) and Liao et al. (2003) and this study posits that social integration mechanisms which foster effective knowledge flow within organisations is a key enabler of the firm's ACAP facilitating responsiveness to environmental changes.

This study found that in particular, gatekeepers of knowledge have a key role to play as they decide what knowledge is disseminated to colleagues. A number of cases mentioned that they have recruited staff with team spirit who would disseminate knowledge. The importance of team work was identified by Penrose (1959). "The firm is a collection of individuals who have experience in working together, for only in this way can 'teamwork' be developed"(1959:46). These findings suggest that while formal knowledge sharing routines such as meetings are important for group assimilation, creating a knowledge sharing culture where individuals disseminate acquired knowledge to colleagues is equally important to the ACAP of HTNVs (see section 8.5.6). Corporate culture can be seen as an enabler in maintaining effective communication as the firm grows. Collective vision means that an individual's intuition which enables them to recognise the value of knowledge will be stronger. By engagement of all staff in key projects, and proactive effective communications, the knowledge flow within the firm can be maintained. This is consistent with the argument that an atmosphere of cooperation encourages individuals to exchange knowledge (Nahapiet & Ghoshal, 1998; Smith et al., 2005).

The findings of this study suggest that group assimilation component of ACAP process is dependent on effective knowledge flows within the firm, and therefore dialogue is essential for effective group assimilation. The findings of this study concur with the early seminal

work on ACAP by Cohen and Levinthal (1990), who noted that cross–functional interfaces increase ACAP. They recognised that knowledge flow within the organisation was key in transferring individual ACAP to firm level ACAP, stating "an organisation's absorptive capacity does not simply depend on the organisation's direct interface with the external environment. It also depends on transfers of knowledge across and within subunits that may be quite removed from the point of entry" Cohen and Levinthal (1990:131). In a recent article, Sun and Anderson (2010) note that subsequent studies have paid little attention to these factors with the exception of three articles (Van den Bosch et al., 1999; Lane et al., 2001; Matusik & Heeley, 2005). Therefore, the findings of this study are particularly valuable to the understanding of the development of ACAP.

This study finds that small HTNVs, have effective knowledge dissemination although they tend not to require formal communications mechanisms due to their size and informal structure. Table 7.12 illustrates the communication mechanisms routinely used within the HTNVs in this study. The findings highlights that due to the limited human capital available in small HTNVs, staff tend to be exposed to more activities that are not directly in their remit and therefore the awareness of issues facing the business are likely to be higher. This study finds that although small HTNVs tend to have no barriers to knowledge transfer within the firm, as the firm starts to grow rapidly, firms have a challenge to maintain effective communication. As organisational structure become more complex, effective communication becomes more of a challenge, especially if staff are split over a number of locations. Furthermore, this study finds that as firms grow and their management becomes more professional, effective communication of issues with the board enables the firm to take advantage of the human and social capital of the board members. It has been suggested that although there has been extensive research into the formal structures that firms put in place to enable knowledge transfer in a structured transfer context, there has been less research in the routines and processes put in place for less structured knowledge transfer (Matusik & Heeley, 2005:555). This study therefore is a step towards addressing this gap. Organisational governance and culture are discussed in 8.5.6.

Intensity of effort was highlighted as key to ACAP by Cohen and Levinthal (1990) and reemphasised by Todorova and Durisin (2007). These findings would suggest that intensity of effort is important in disseminating knowledge appropriately throughout the

firm. These findings also concur with the view of King (2006b) suggests that once knowledge has entered the firm's knowledge stores, it must be either transferred or shared. King (2006b) highlights these two ways of dissemination: the simple sharing of knowledge (making it available) and transfer (a more active process of codifying knowledge in the organisational memory). This study found that a number of case firms made a particular effort to communicate effectively between teams and recognised that as the firm grew in employee numbers, they needed to put more formal communication channels in place to address the risk of silo effect.

Echoing the work of Weiss and Heide (1993), this study acknowledges that firms must make use of new external knowledge before it becomes dated and loses its value. Therefore, efficient knowledge sharing and dissemination within the firm enables the firm to capitalise on new opportunities (e.g., Mu et al., 2010). Discussion of the issue of wide dissemination also raises some conflicting views from those that posit that wide dissemination of knowledge leads to seepage of knowledge (e.g., Mohr, 1996) out of the firm, which is a threat to the firm's profitability.

Following the above discussion, the following proposition may be made:
Text Box 8.13

Proposition 10:	HTNVs with effective social integration mechanisms have enhanced ACAP as they have a more effective group assimilation capability.

8.5.5 The management of knowledge stocks as an enabler of ACAP

This study finds evidence to suggest that the management of knowledge stocks is a key enabler of ACAP. The life science industry is one where knowledge stocks are actively managed through the development of documented routines. This is for two main reasons: firstly, the development of intellectual assets must be rigorously documented in order to enable the patenting of innovations; Secondly, as the life science industry is heavily regulated, all new processes, products or services developed must have standard operating procedures associated with them that ensures that the therapeutic drug, diagnostic or

reagent is exactly the same each time and the quality/ethics standards are upheld. The evidence would suggest that as a result of these documented routines, the knowledge stocks in HTNVs in life sciences are by necessity well managed, which is consistent with the findings of Lennox and King (2002) who found that the presence of routines for quality initiatives facilitated the adoption of future quality related practices, and earlier work suggesting that knowledge stocks are held in the firm's general routines and processes (Nelson & Winter, 1982; Teece & Pisano, 1994; Zander & Kogut, 1995; Grant, 1996; Teece et al., 1997). For example, one of the cases further developed their TQM systems to meet customer requirements, but in addition to servicing the needs of that customer, this is a routine/capability that all future business can benefit from. This would suggest that it is the development of new routine, processes, procedures, documentation, systems that ingrain that knowledge into the fabric of the business/organisational memory and add to the collective knowledge stocks of the firm. This suggests that these firms have the functional ability to leverage knowledge from the environment, and the creation of a routine has an impact on their ability to do it again (Srivastava et al., 1999). This has parallels to Vega-Jurado et al.'s (2008:396) notion of formalisation. The findings of this study suggest that HTNVs should have an effective knowledge management process in place for codifying the knowledge individuals hold in order for the firm to benefit in the future. This evidence also supports Easterby-Smith and Prieto (2008), who propose that knowledge management-enabled dynamic capabilities have an impact on business performance.

Following the above discussion relating to the management of knowledge stocks, the following proposition may be made:

Text Box 8.14

Proposition 11:	HTNVs with effective knowledge management strategies have enhanced ACAP, enabling the exploitation of knowledge.

8.5.6 Organisational culture and governance as enablers of ACAP

Organisational culture has been identified in this thesis as having a key role in enabling the ACAP process. In particular a number of firms in this study discussed the importance of culture of empowering staff to proactively look for improvements to processes, cost efficiencies, new product development opportunities. Building on Easterby-Smith et al.'s (2008:496) discussion of episodic power and Cohen and Levinthal's (1990) emphasis on 'intensity of effort', this study highlights the importance that individuals feel empowered to search widely for knowledge and act on the knowledge they acquire or have access to. It has already been highlighted that organisational culture impacts on social integration mechanisms within the firm which are discussed separately in section 8.5.4. This finding is also consistent with other authors (e.g., Kanter, 1985; Daghfous, 2004; Murovec & Prodan, 2009) who highlight the importance of a culture that embraces change for assimilation of knowledge. The findings from this study suggest that the culture of open innovation which exists in many HTNVs is a key enabler for the leverage of external knowledge.

This study also finds that the ability to act upon knowledge is often enabled by the governance and structure of the firm. For example, the ability of R&D teams to make decisions about new product development can affect the speed that the firm can react to an opportunity. Governance of the firm can have an impact on the firm's flexibility to react to environmental changes. Firms with Venture Capital investors can be prevented from acting on a new opportunity, due to the need to meet agreed investor milestones. On the other hand, knowledgeable investors that understand the industry can contribute valuable knowledge in addition to the finance is also key to successful exploitation.

The governance of the firm also impacts on the organisational structures that are put in place, and the organisational culture that is adopted. As the firm grows the organisational structure changes as new employees join the firm, which in turn impacts on the knowledge flows within the firm. These findings are consistent with Zahra and George (2002b) who note the impact of organisational structure on social integration mechanisms.

Following the above discussion, the following proposition can be made:

Text Box 8.15

Proposition 12:	HTNVs that optimise their organisational culture, structure and governance to maximise empowerment and knowledge-sharing have enhanced ACAP.

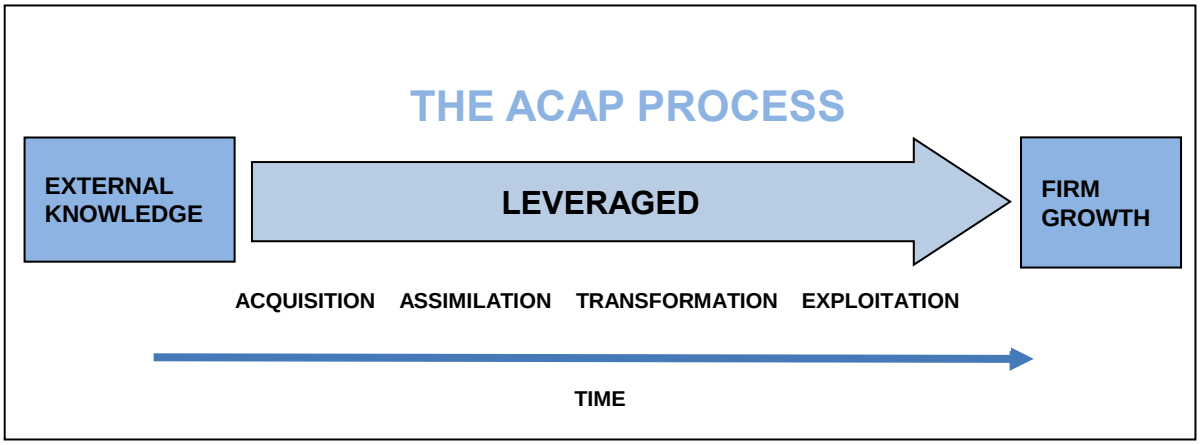
8.5.7 Investment of resources as an enabler of ACAP

As highlighted in Chapter 7, the leverage of knowledge has required significant investment of resources, which impacts on the presence of all other enablers of the ACAP process. In addition to financial investment, Consistent with Cohen and Levinthal's (1990) views on intensity of effort, HTNVs in this sample have to invest considerable resources in terms of management time at each dimension of the ACAP process in order to successfully leverage knowledge, and this is particularly evident at the transformation dimension where management capacity to allocate time to evaluating new opportunities by combining new knowledge with existing knowledge stocks is an enabling factor in the leverage of external knowledge. This is discussed further in the next section.

8.6 Temporality of ACAP

Despite the recognition of the importance of speed in development of dynamic capabilities in response to environmental changes, researchers have not recognised the temporal aspects of ACAP (Zahra & George, 2002b). This study finds evidence that in dynamic high-technology markets, the speed of exploitation of knowledge can have a significant impact on the growth outcomes for HTNVS. However, it also has uncovered that building resources and capabilities to respond to market opportunities takes time and that as new products/services are being developed, HTNVs must be watchful to changing market conditions. Furthermore, this study also finds that firms need to deal with the challenge of exploiting current knowledge assets while exploring future opportunities. This study also sheds light on the proactive building of relationships in order to access the knowledge the firm will require once their product is developed. The temporal lens provides an important framework for explaining and understanding behaviour (Ancona et al., 2001) and therefore by examining this dimension, this study makes a significant contribution to the ACAP theory by highlighting 3 key temporal aspects in relation to the ACAP process: the time it takes to exploit new external knowledge, the timing of acquisition of new knowledge, and the investment of time as a resource in building ACAP.

Figure 8.3 The temporality of the ACAP process



Source: Developed by the researcher, adapted from Zahra & George (2002b:192)

8.6.1 Speed of leverage of knowledge through the ACAP process

This study demonstrates that the leverage of knowledge through the ACAP process occurs in a number of iterative steps over a period of time. The findings from this study suggest that it is difficult to measure the temporality of the absorptive process in real time, as the firm's ACAP is a function of the cumulative prior knowledge and experience of individuals within the firm, in addition to the shared knowledge stocks within the firm. For example in a number of cases, the timeliness of the acquisition of a new piece of knowledge can be the 'tipping point' (Gladwell, 2000) that makes the firm decide on a particular course of action. The evidence suggests that this may have been a potential opportunity already known to an individual or the firm for a number of decades, but which required a change in the environment to become viable opportunity for the firm. In high technology industries, it can take time for other advances in science to enable the exploitation of knowledge assets possible, or for the market to be in a position to adopt a new product. Attempting to take a product to market too early might result in low adoption of the product. This suggests that timing, sequencing and path dependency is also a key aspect of the temporality of the ACAP process.

- *Building of stocks of knowledge within the firm takes time*

This study finds that in a number of cases, an initial acquisition and assimilation of knowledge, which highlights a potential opportunity to the firm, needs to be supported by further evidence in order to merit significant investment that may be required to exploit the opportunity. The firms in this study can be seen to acknowledge the opportunity but not act on the initial information until they have acquired significantly more knowledge to enable an investment decision. As highlighted in the exploitation section, in a number of the firms within this study, there has been a considerable time-lag between the initial recognition of an opportunity, which is temporarily 'parked' and the willingness or ability to act upon it. This study highlights that HTNVs may need to build different stocks of knowledge simultaneously to enable the firm to exploit the opportunity it has identified. HTNV add to both their individual and firm knowledge stocks by investment in R&D, employing highly qualified personnel and investment in training of their staff.

- *Speed of leverage of new external knowledge*

New product development is a more easily observable outcome of the ACAP process, so this is selected as an example of the time taken to leverage knowledge from acquisition to exploitation. HTNVs are founded to capitalise on technological innovation, and therefore understanding how the ACAP process can take new innovative products to market quickly is key to the survival and growth of these firms, as there are significant benefits to being first to market (e.g., Ahuja & Lampert, 2001). Patent protection and exclusivity on the technological innovation is for a limited period of time and therefore, the speed of commercialisation of products or services is crucial. As a result, the faster that value can be leveraged from external knowledge through the ACAP process, the faster a firm can grow. Table 8.4 provides some examples of the time taken from knowledge acquisition to a new product or service development outcome from the process.

Table 8.4 Examples of time taken from knowledge acquisition to NPD outcome

Case	Acquired knowledge	New product or service	Timescale (years)
A	New market opening up (MK) New xxx developed by academic link (TK)	Production capacity increased and quality standard accreditation New xxx in product portfolio	5 years (approx.) <6 months
B	Customers and potential customers demand for xxx (MK)	New validated assay services developed and marketed	3 years (approx.)
D	Customer demand for xxx (MK)	xxx sourced and service marketed	<1 year
E	Prior to foundation (TK) xxx pandemic (MK)	Safety testing for xxx vaccines	<6 months
F	Prior to foundation (TK) Prior to foundation (MK)	Product on the market	<2 years
G	Prior to foundation (TK) Prior to foundation (MK)	Diagnostic assay kit in development	20+ years (2.5 in firm)
I	Prior to foundation (TK, MK)	Product developed Awaiting regulatory approval	25+ years (3 in firm)

Source: Categories developed from matrix analysis of case studies

This study finds that while some are very fast indeed, others appear to be extremely slow. The challenge is to understand to causes of these differences in exploitation time. For example, in Case G, there is an almost twenty-year delay between recognising the potential of a particular technology and the commercial exploitation of that technology. For this

firm, the assimilation of technical knowledge led to an understanding that there was potential for this technology as a diagnostic test, but the market did not exist and it took significant time for the market dynamics to be such that commercial exploitation was possible. HTNVs use their ACAP to recognise that an opportunity is now viable.

This study has found that firms (cases A&E in particular) with significant product/service development experience, established NPD processes and routines, and with established routes to market, can be seen to quickly take advantage of new external knowledge and launch new products and services. This study also finds that in newly established HTNVs such as case F, the speed of commercial exploitation of innovations from the time of company foundation and product launch is accelerated when the firm has access to all the knowledge it requires and a number of enablers are present, such as prior experience and knowledge of the sector, and connections. The integrated entrepreneurship approach has revealed that as firms that are part of global value chains endeavour to launch products and services in multiple international markets, established links with the market or distribution channels are of particular benefit to the speed of commercial exploitation. This reinforces the interwoven nature of the drivers of growth and the view that it is the interaction of a number of enablers of the ACAP process (i.e. elements of human, social, organisational and financial capital) that accelerate small firm growth (see section 2.10). Furthermore, stocks of experiential knowledge reduces the time that can be spent following leads that finish in the dead ends/false starts that so many start-ups encounter as the firm learns. The presence of a combination of enablers gives confidence to investors in the management's ability to exploit the knowledge assets, and they in turn provide a further enabler, investment. This study also highlights that in HTNVs that have less experiential knowledge, this can be seen to be improved recruiting experienced board members to address the gap in their ACAP.

As Chapter 2 highlighted that knowledge moderates the pace of both innovation and internationalisation, these findings would predict that HTNVs with multiple enablers of ACAP present can commercialise innovations in global markets more effectively.

- *Building knowledge assets and capabilities takes time*

This study has found that once a firm decides to invest in the creation of a new knowledge asset or a capability to capitalise on an opportunity it has recognised as a result of assimilating external knowledge, there can be a significant time lapse as that knowledge asset or capability (For example, building a portfolio of evidence to validate an assay, conducting clinical trials, or the building of specialist manufacturing facilities) is created that enables the firm to exploit that opportunity. The firm may have to raise additional funding to realise that opportunity and this again takes time. In some cases the firm needs to wait until it has made revenues from initial lead products in order to reinvest in new product development.

This study finds that for some product or service development, it is an incremental innovation where new technology can be easily added to existing knowledge assets and transformed into a new product or service, this ACAP process can be very rapid indeed. In these situations, the knowledge asset created may have limited value, the IP is often not patented and the objective for the firm is to make as much revenue from the opportunity as possible by getting to the market quickly. More complex product development, which ultimately has more value, has IP associated with it, and is a longer process. These findings echo the views of Brown and Eisenhardt (1998) who suggest that dynamic capabilities require a firm to have two temporal orientations: the present and the future, and McGrath (2001) who suggests that the present involves incremental innovation that is linked to the dominant industry design, whereas preparing for the future involves learning about alternative futures, technological discontinuities and evolving technology cycles. Where product development is complex requires further innovation, or acquired and assimilates knowledge which result in the decision to create new capabilities to enable the firm to move into a new market.

- *Exploitation of capabilities takes time*

This study finds that although a firm may assimilate knowledge from potential customers that quality and reliability of service is of great value, and put routines in place in order to create a service capability which matches expectations in the marketplace. However, it

takes time and in the cases of three firms in this study, a number of small trial contracts before volume orders are placed. In another case, the firm has created the capabilities required to enter a new market, and built a number of relationships into customers with small orders, but the lead time to a large volume order can be significant. The decision to place larger orders is dependent on a drug moving to the next stage of clinical trials, which is outwith the control of both the firm and its customer.

From these findings, this study concludes that there is a time lag before the ACAP process yields a growth outcome and that time lag is very dependent on the context within which the process is embedded. This is consistent with the findings of the recent study which states that ACAP can be a source of financial advantage over time (Kostopoulos et al., 2011:1341). Internal resources (i.e. finance, human and social capital) and external environment (regulation, market dynamics, and competitor activity) have a significant impact on the outcomes. These findings also support Zahra and George's (2002b:196) proposition that effective timing of capability deployment is a key dimension of a well-developed PACAP.

8.6.2 Timeliness of knowledge acquisition

Consistent with Glaser and Weiss (1993), this study finds that information in fast-moving environments such as the life science industry is time sensitive. HTNVs must acquire and assimilate external knowledge in a timely fashion in order to capitalise on it before the knowledge becomes dated. It is interesting to consider whether the firms seek and assimilate knowledge relating to the challenges they are currently facing or whether they anticipate knowledge required for the next growth stage and acquire assimilate in advance. While some knowledge acquisition is serendipitous, there is evidence of firms understanding their future knowledge requirements, and planning their knowledge acquisition in advance as technology is being developed. For example, this study highlights that HTNVs are proactively building social capital in order to be able quickly to source the market knowledge they require when they need it. The creation and enhancement of ACAP includes the ability to build social capital which can assist the firm's requirement for knowledge in the future. Ensuring that the firm has access to market knowledge so it keeps up to speed with market developments is vital for growth but

in a fast moving industry, being aware of advances that may create disruptive technologies and the speed of adoption may also be key to survival.

8.6.3 Investment of management time in building ACAP

Management time is a resource and, particularly in a small HTNV, one which is scarce. Therefore, any time invested in building ACAP relative to other activities must be justified. The firm has to value time spent in training or in building links with the industry in order to build stocks of knowledge and in turn ACAP. The traditional view is that firms build ACAP as a by-product of other activities and do not dedicate time to it. However, since the firm required the ACAP to be able to assimilate knowledge from outwith the organisation, building this capability allows the firm to generate more options, and make more informed choices (McGrath, 1999) about future opportunities, enhances organisational responsiveness (Liao et al., 2003). As already highlighted, it takes time for management to evaluate new technological opportunities and small HTNVs that are very focused on their core technology may not invest the time in putting the enablers of the ACAP process in place to facilitate the leverage of knowledge.

This study suggests that the building of ACAP is essential to prevent the firm from missing or getting locked out of key technological advances or missing an opportunity. As this study has highlighted that the development of ACAP is cumulative and path dependent, it should also be noted that this cannot be done in a short period of time. This study is in agreement with Liao et al. (2003) in suggesting that investment in ACAP should begin as early as possible, and should be continuously added to enable the firm to maximise its leverage of external knowledge from the environment.

The culmination of the previous discussion of temporal issues enables the following propositions to be made:

Text Box 8.16

Proposition 13.1:	The speed of leverage of knowledge by HTNVs at critical events is enhanced by the synergistic presence of multiple enablers of ACAP.
Proposition 13.2:	HTNVs with well-developed social capital achieve timely acquisition of external knowledge and faster leverage of that knowledge, enabling efficient resolution of growth challenges by HTNVs.
Proposition 13.3:	HTNVs that proactively invest time and resources in building ACAP and its enablers, have an enhanced ability to resolve growth challenges at critical events.

8.7 Contributions of this study: Theory and Practice

8.7.1 Contribution to theory

This study not only makes a contribution to the small firm growth literature, but also to the development of theory on ACAP.

What does this mean for the development of the ACAP theory?

This study reinforces the importance of previous work on ACAP, and furthermore it extends ACAP theory by proposing a new process model of ACAP (Figure 8.1) and highlighting the combination of enablers required at each dimension of the process (Table 8.1):

1. The most important contribution of this study has emerged from incorporating a number of other findings relating to enablers of ACAP and temporality of the ACAP process, which together suggest that the speed and efficiency of knowledge leverage through the ACAP process at critical events is maximised when HTNVs have a number of enablers of ACAP present and operating synergistically. Zahra and George (2002b) called for researchers to recognise the temporal aspects of capability development. This study enhances the understanding of temporal aspects of ACAP (speed, timing and investment of time) and the impact of enablers on the temporality of ACAP.

2. This research also contributes to ACAP theory by highlighting social capital as a key enabler of ACAP, in that the ability of HTNVs to leverage knowledge is dependent on the firm's ability to establish and maintain relationships with its external constituents in order to access new external knowledge. HTNVs that are aware of social capital as an enabler of ACAP build relationships that facilitate the timely acquisition and faster leverage of knowledge at critical events. In addition to the role of social capital in knowledge acquisition, previously identified by Yli-Renko et al. (2001), this research indicates that social capital has a key role in the assimilation of knowledge. This adds to the work of Lane et al. (2006) who identified relationships as easing understanding. This study also extends development in both ACAP and social capital theory, in defining the types of social capital which impact on the firm's ability to leverage

knowledge at each of the different dimensions of ACAP. The findings from this research therefore suggest that the possibility of bridging the gap between ACAP theory and network theory is closer.

3. The reconfigured process model of ACAP increases understanding and advances the ACAP field in a number of ways:

- The model demonstrates that the ACAP process is a cyclical, iterative and cumulative process that builds stocks of knowledge within the firm at each cycle. Highlighting the temporal dimension, this study suggests that multiple cycles over time are required to reach a commercial outcome. The majority of existing ACAP literature, while acknowledging the path dependent nature of ACAP, represents it as a linear process. For example, Zahra and George (2002b:196) state that "externally acquired knowledge undergoes multiple iterative processes". Although some previous models (Lane et al., 2006; Todorova & Durisin, 2007) have included feedback loops in their models, they do not fully explain the iterative and cyclical nature of the ACAP process, or the nature of the cycles through acquisition, assimilation and transformation prior to exploitation. This study therefore adds significantly to the understanding of the ACAP process.

- This model identifies the key enablers that are required to facilitate each stage of the ACAP process. In particular this study highlights the internal enablers which are within the control of the firm, proposes that firms require multiple enablers working synergistically to effectively leverage knowledge.

- This model acknowledges that ACAP is a multi-level construct. Building on Cohen and Levinthal's (1990) recognition that organisational ACAP is dependent on the ACAP of its individual members, this study defines the dimensions of individual-level ACAP (recognising the value, acquisition and assimilation), and bridges the connection between the two elements of ACAP (individual- and firm-level ACAP), highlighting how firms can harness and maximise the value from individual-level ACAP, through establishing an appropriate organisational culture and social integration mechanisms. The model also highlights that assimilation occurs both at

individual and firm level. In developing this model, this study bridges the gap between the entrepreneurship researchers that focus on the individual and the innovation researchers that highlight the social aspect of innovation, making a compelling argument for how these two views can be accommodated. While some scholars (e.g., Cohen & Levinthal, 1990; Lane et al., 2006) have acknowledged that ACAP exists at these two levels, the articulation of the relationship by this study adds to the fields understanding of ACAP. Building on the work of Zahra and George (2002b), this model highlights the importance of effective social integration mechanisms, as a key enabler of group assimilation, working synergistically with other enablers to harness the power of individual-level ACAP to enhance firm-level ACAP.

- This model highlights how the dimensions of the ACAP process work to build the firm's stock of knowledge, building on Lane et al. (2006) who highlight the knowledge outputs of the ACAP process. There is a reciprocal relationship between the development of knowledge stocks and the development of ACAP. Furthermore, given the impact of knowledge outputs for the future business performance, this study highlights knowledge management as a key enabler of ACAP, building on Easterby-Smith and Prieto (2008).

4. This research highlights that the ACAP process transcends the functional boundaries of the firm and is determined by the context of the complex combination of challenges the firm is facing both within the firm and in the industry environment in which it operates. As previously discussed, the three key integrated entrepreneurial processes (innovation, internationalisation and entrepreneurship) tend to be studied in isolation. This study finds that for successful leverage of external knowledge, the knowledge processes within the firm must cross functional boundaries as the firm uses its ACAP to assimilate and combine knowledge from across all departments within the firm. The majority of previous research in ACAP has been focused on R&D (Lane et al., 2006) and technical knowledge, this research takes a more holistic approach to understanding the firm's knowledge processes, looking at all areas of the business and all types of knowledge. This model highlights 6 types of knowledge (market, technical, managerial, regulatory, internationalisation and relational) required by HTNVs and notes the importance of a market awareness for HTNVs in order to maximise the

growth outcomes from the ACAP process.

What does this study mean for small firm growth literature?

1. By identifying the challenges that HTNVs face at identified critical events, this study finds evidence to suggest that at critical events, HTNVs must have the key drivers of growth (innovation, internationalisation and entrepreneurship) in syncopation in order to successfully resolve challenges and enable the growth and development of the firm. Taking a holistic approach to key integrated entrepreneurship processes, this thesis demonstrates that internationalisation is essential for the commercial exploitation of knowledge by HTNVs in global industries such as life sciences. Given the lack of holistic approaches to the growth of HTNVs in existing literature, this study contributes further to literature on small firm growth, building on research by Jones (1999) and Onetti et al. (2010), bringing insights from the fields of innovation, internationalisation and entrepreneurship together, and highlighting the role of knowledge processes in the growth and performance of the firm.

2. This research highlights that HTNVs that are aware of social capital as an enabler of ACAP build strategic relationships that facilitate the timely acquisition and faster leverage of knowledge at critical events, thus facilitating their growth. It is widely recognised that HTNVs have limited stocks of knowledge with the firm, and although their demand for knowledge to resolve complex challenges is acute (Phelps et al., 2007), the resources that these firms can invest in building stocks of knowledge is limited. The findings of this study suggest that HTNVs utilise social capital to substitute for deficiencies in the firm's stocks of knowledge, identifying the types of social capital which facilitate the resolution of particular challenges. In particular, this study highlights the use of the social capital of board members for this purpose. This supports the work of George et al. (2001) and Zahra et al. (2009) who note the importance of board member connections to the external environment. These relationships enable HTNVs to source the knowledge they require without having to spent time and resources developing that knowledge themselves. This study furthers the understanding of how social capital acts as a key mechanism by which HTNVs overcome the limitations of smallness and newness and quickly capitalise on market opportunities.

3. This study highlights the value chain issues for HTNVs, which provided specialised niche products and services in a complex value chain. For HTNVs, the creation of value is highly dependent on the fortunes of larger players further down the value chain. In niche markets, where HTNVs tends to supply much larger downstream players their product/service (Gassmann & Kuepp, 2007), the fortune of the limited number of customers has a considerable impact on the firm's ability to grow. This raises the importance of investing in developing relationships with potential customers early in the technology development process. The ability to transform relationships into appropriate knowledge transfer structures and to do appropriate commercial deals is essential to enable the firm to achieve a return on their investment. There is a constant requirement for re-evaluation of how changes across the value chain in the industry impact on the firm in terms of opportunities and threats. The investment in the development of appropriate social capital in the form of links across the value chain facilitates the evaluation of opportunities and threats. Therefore, this research proposes that the creation and strengthening of relationships and collaborations, both upstream and downstream within the value chain are key enablers of HTNV's ability to leverage knowledge for the growth and development of the firm.

   Although HTNVs have high internal stocks of technical knowledge, this study highlights the importance of 'open innovation' (Chesborough, 2003) for HTNVs and found that these firms leverage a combination of knowledge types (market, technical, managerial, regulatory, international and relational) to resolve growth challenges at critical events. This study builds on the work of Pisano (2006) and Fabrizio (2009), who emphasise the need for life science firms to integrate knowledge across diverse knowledge sources. Tacit market knowledge was found to be of particular importance to HTNVs and therefore, engagement with the marketplace is of key importance for the growth of HTNVs. The findings suggest that HTNVs can increase their potential for growth by developing a marketing awareness and building relationships with appropriate players in the market place at an early stage in order that products and services that are appropriate to market requirements are developed. This study also highlights the importance of collaborations with external organisations to capitalise on growth opportunities. As small firms often cannot deal with growth opportunities themselves, the formation of collaborations enable partners jointly to service that

opportunity. This study has shown the importance of building links with potential partners in order to be aware of complementary capabilities.

4. This study highlights that stocks of knowledge in HTNVs are held in the human capital of the firm, by both individuals and in specialist teams. As the firm requires new knowledge to resolve growth challenges relating to critical events, the task of acquiring the external knowledge required by the firm is often on the CEO and a few other key individuals that act as gatekeepers, and their ability to assimilate that knowledge and understand its implications may be limited to their personal knowledge and experience Building on entrepreneurship research (e.g., Shane, 2000, Ucbasaran et al., 2001) relating to entrepreneurial opportunities, this study highlights that opportunity recognition in HTNVs is dependent on the ACAP of a few key individuals recognising the value of knowledge, which is dependent on their ability to be 'atuned' to combinations of explicit and tacit knowledge. Human capital is limited in all HTNVs, and this impacts on the management capacity to act on market opportunities.

   This study highlights that HTNVs recruit additional human capital to fill gaps in their both their stocks of knowledge and their ACAP, including new staff members and board members. However this study contributes to the small firm growth literature by highlighting that in addition to the individual's experience and knowledge, their social capital is particularly useful to enable HTNVs to access further knowledge. In particular, this study suggests that appropriate changes in the composition of the Board of Directors of HTNVs can play a key role in the timely acquisition of knowledge the firm requires to transition through growth challenges. This builds on the work of Zahra and Filatochev (2004) on the governance of threshold firms.

8.7.2 Contribution to policy makers

The findings of this study have particular relevance for policymakers. As government bodies as national and international levels have placed the growth of HTNVs at the centre of their agenda, consequently, policy makers have placed a great deal of emphasis on supporting HTNVs. Therefore, insights on the challenges these firms face and their

complex knowledge requirements provide suggestions as to how agencies can better design and deliver interventions that support growth of HTNVs.

1. This study has highlighted the complexity of the challenges facing HTNVs, and being small with limited experience and resources, the firm is unlikely to have the knowledge within the firm to address these challenges at any given time. Given the limited time window to these firms to capitalise on market opportunity, timely and appropriately focussed advice from development agency services which enables HTNVs to address the multiple challenges associated with critical events and transition into the next phase of growth would be of significant benefit to the economy.

2. The importance of external knowledge for the resolution of challenges at critical events has been widely recognised (Kazanjian, 1989; Veugelers, 1997; Phelps et al., 2007). This study highlights that individual enablers of the leverage of knowledge through the ACAP process do not work in isolation. Therefore, a key implication of this study is that policy makers should create a company diagnostic tool comprising of a checklist of internal enablers of ACAP identified by this study, which can be used as a component of interventions with HTNVs, with the objective of assisting the firm to put in place mechanisms to facilitate the leverage of external knowledge.

3. This study has shown the importance of market awareness for HTNVs, and the need for these firms to be attuned to the requirements of the market. Therefore policy makers should instil a sense of market awareness in the young HTNVs that they mentor, encouraging them to be attuned to customer needs, market dynamics and industry drivers at the early stages of technology development, in order to develop products and services which match the needs of the market place. In particular, as HTNVs tend to be at the R&D end of complex value chains, policy makers can assist HTNVs to make connections across the value chain. The importance of making appropriate connections with the market place should be emphasised by entrepreneurship programmes provided to young research scientists, so that they are encouraged to utilise the building of links as a cost effective mechanism to acquire and assimilate external knowledge they require to create and grow HTNVs.

4. As this study has shown that HTNVs can seldom capitalise on a market opportunity alone, interventions by economic development agencies aimed at supporting the growth of HTNVs should include the provision of advice and support for developing partnerships and collaborations, with a view to maximising the opportunities for growth.

5. This research suggests that in the complex value chains that exist in high-technology industries, both the ACAP of organisations that require knowledge and the market awareness of those that could provide the relevant knowledge may not be optimal, which blocks knowledge transfer. Therefore, networks and intermediary organisations may be key to the effective transfer of knowledge between parties in the value chain. Therefore, policy makers should consider supporting knowledge transfer intermediaries as part of high-technology industry cluster development.

6. This study has shown that the relevant experience and social capital of well-connected board members can be of significant benefit to HTNVs, in bringing in specific knowledge and contacts to address a particular challenge facing the firm in a timely manner. As part of the provision of support for strategic planning to HTNVs, government agencies should provide advice to the management of HTNVs regarding the benefits of strengthening and refreshing their Board of Directors, in order to maximise the effectiveness of the Board in assisting the firm with current and upcoming challenges.

8.7.3 Contribution to practitioners

The contribution that this thesis makes to practitioners is intended for the leaders of HTNVs. This research was motivated by a desire to assist practitioners to access the knowledge they require at events critical to the growth of the firm. Therefore, by developing a deeper understanding of the complex challenges faced by HTNVs at critical events, and in identifying how to optimise the timely inputs of knowledge and enhance the efficiency of its leverage, this thesis makes a significant contribution to practitioners. This contribution is complementary to the contribution this thesis makes to policy makers, which has been detailed in the section above.

1. The temporal aspects of ACAP that have emerged from this thesis provide important insights for practitioners. Given the relatively short windows of opportunity in dynamic knowledge-intensive industries, management teams of HTNVs should consider proactive investment in the enablers of ACAP that will enhance the firm's future ability to leverage knowledge to rapidly resolve challenges at critical events. As this study suggests that all enablers of the ACAP process are required in order to effectively leverage knowledge, HTNVs should regularly evaluate their levels of particular enablers, addressing deficiencies. For example, firms should focus on increasing knowledge stocks in the areas which will underpin the future development of capabilities that deliver growth, thus increasing ACAP. This study suggests that the investment of management time in enhancing ACAP enables better organisational responsiveness.

2. This thesis has highlighted social capital as an enabler of the leverage of knowledge and has found that building relationships with key market players across the value chain can be a cost effective way of gaining valuable market knowledge. Having links of a particular nature increase ACAP. Given the intangible nature of both ACAP and the outputs of building links, a firm may be reluctant to sacrifice output in other areas in order for staff to build social capital. Therefore, highlighting the benefits of building appropriate social capital to the firm's ability to acquire and assimilate external knowledge in a timely manner is an important outcome of this research for managers. Managers should also optimise their ability to leverage external knowledge by maximising their use of knowledge transfer intermediaries that can help with making the appropriate connections.

3. Building a strong management team with experience has always been considered important. This study has shown that building a strong board of well-connected non-executive directors can be a particularly valuable source of short-term input of knowledge that the firm needs to overcome a particular hurdle. This study also highlights the benefits of knowledgeable sector specific investors and their links as a way to enhance the absorptive capacity of the firm. Furthermore, this study advocates the benefits of changing board members to ensure that the board has the combination of skills to deal with combination of challenges that the firm is facing.

4. This thesis has highlighted the importance of early market awareness for HTNVs, ensuring that they engage with customers across the value chain at an early stage in product development, in order that their product or service matches the requirements of the market. Furthermore, the attuning of marketing materials in order to reflect how the firm can address the needs of customers rather than the common focus on the firm's the technical capabilities may enable HTNVs to gain more business.

8.8 Limitations of this research

The limitations of this research presented in this thesis are predominantly methodological. Although the case study approach was chosen in order to provide a rich contextual understanding of the leverage of knowledge by HTNVs, it presented some shortcomings:

- The leverage of knowledge by HTNVs in the sample was found to be a lengthy process with considerable time lag from initial recognition of the value of knowledge to exploitation of that knowledge by the firm, due the lengthy value chains and product approval processes in the life science industry. In the time permitted for doctoral research, a number of firms had not fully realised the growth outcome, albeit that they were well positioned to do so.

- Historical critical event analysis, based on retrospective accounts of managers of sample HTNVs, was a key tool in building the in-depth case studies in this thesis. However, retrospective accounts rely on the memories of the key respondents within each firm to provide an accurate account of events. There is a risk that memories of events are often inaccurate and subject to bias. This issue has been addressed by triangulation.

- As this research methodology is in-depth case studies, the findings are less generalisable. However, the insights from this research can inform future research which could cover a greater sample and be more representative. Furthermore, similar patterns of knowledge leverage found in this study within the life science industry may be found in other small firms in high-technology sectors, so this study can still provide useful insights to the practitioners in knowledge intensive industry sectors.

- This research selected cases in the explanatory phase of data collection by purposive sampling, choosing firms that demonstrated evidence of leveraging knowledge. Therefore, although the sample of in-depth cases provided valuable insights on how HTNVs leverage knowledge, the sample did not have examples of firms that had not successful leveraged knowledge.

- Although the number of cases selected enabled a spread of maturity and subsectors of the life science industry in the sample, the large volume of data generated by the number of cases meant that some of the richness was lost in the presentation of the findings. For example, in order to manage the data analysis and to present findings, a structured approach was followed using text tables, as recommended by Miles and Huberman (1994); some of the richness was lost where direct quotes from respondents and context from some cases were not used to supplement discussion.

8.9 Future research directions

- *ACAP and temporality*

This study has highlighted that the temporality of ACAP is important for the growth of the firm, but this is just the start of this discussion. This study reinforces that in dynamic industry environments, access to timely inputs of knowledge and its subsequent exploitation can be crucial to the ability of HTNVs to respond quickly to challenges they face. Therefore, further definition of the temporal nature of ACAP would add to the understanding of ACAP. Enablers of ACAP could be further categorised according to the significance they have on the temporality of ACAP, and in particular on the pace of knowledge leverage. Given the significant time delay in the exploitation of external knowledge, longitudinal studies would assist in this endeavour.

- *ACAP and social capital*

Although this study suggests that links could be an important determinant and antecedent to the ACAP process, this has not been examined in depth. Further empirical studies are required to examine the extent to which different types of links enhance the ACAP process

and impact most on the growth of the HTNV. The temporal aspects of social capital and ACAP are interesting avenues for future research. Longitudinal studies might provide insights into the understanding of temporal delay between links being established and knowledge being acquired, suggesting the optimum time for HTNVs to build relationships. Even though links can be a very cost effective means to gain access to new external knowledge, in resource poor HTNVs, establishing links can be a costly endeavour and the firm has to prioritise developing these links alongside other key activities. Therefore empirical studies should examine the level of resource (time and financial) investment by the firm to create, develop and maintain relationships and the value of external knowledge acquired via that route. For example, a future empirical study could investigate how ACAP is enhanced by particular links but also measure the direct performance outcomes that result.

- *Social capital of board members and the leverage of knowledge*

This study found that board members and their links had a significant impact on both the acquisition and assimilation of new external knowledge. However, this was an emergent finding which, although particularly interesting, was not in the research objective and therefore not examined in depth. Furthermore, due to the small sample this study cannot generalise about how HTNVs utilise the connections of their board to leverage knowledge. Therefore, further studies both in-depth qualitative and wider quantitative studies of the use of board member social capital, including the temporal aspects of networking with respect to resolving challenges being faced by firms would add valuable insights to the growth and development of HTNVs.

- *Gaps in knowledge flow*

The model of ACAP process developed by this study identified potential blocks to knowledge flow but these have not been fully explored. For example, this study has identified that firms 'park' new product development ideas. Future research into gaps in knowledge processes, with a view to suggesting bridges to these gaps in knowledge flow would enhance the firm's ability to leverage knowledge to assist in its growth.

- *ACAP and market orientation*

This study has highlighted the importance of acquiring and utilising market knowledge for the resolution of growth challenges faced by HTNVs. In particular, having an awareness of customers and key stakeholders across the value chain are key to HTNVs that are positioned within complex global industries. While ACAP literature traditionally tends to look at the research and development end of the development cycle, market orientation (Kohli & Jaworski, 1990) is peculiar to the marketing literature and looks specifically at how firms orientate themselves towards their markets. The findings of this study suggest that future ACAP research needs to interface with the concept of market orientation.

8.10 Concluding remarks

This research was motivated by the desire of the researcher to assist practitioners in HTNVs by developing a deeper understanding of the challenges faced by HTNVs, and how these firms source and leverage knowledge to address these challenges to enable their growth and development.

Taken together the findings of this study highlight the complexity of the challenges faced by HTNVs at critical events. The holistic approach to key integrated entrepreneurial processes has highlighted that HTNVs require all three key drivers of growth (innovation, entrepreneurship and internationalisation) to work in syncopation to resolve these challenges to enable the growth and development of the firm. HTNVs have an acute demand for external knowledge to assist with the resolution of these multiple simultaneous challenges, and the knowledge requirements are equally complex, necessitating a combination of six different knowledge types.

This study found that the leverage of external knowledge through the ACAP process is cyclical, iterative and cumulative over time, with the HTNV building its stocks of knowledge at each cycle. The process is enabled by a number of factors working synergistically which enhance the ability of the firm to leverage knowledge. The timeliness of acquisition, assimilation, transformation and exploitation of knowledge is crucial to the firm's ability to quickly resolve challenges and enable the growth and development of the

firm. Therefore, this study in identifying how to optimise the timely inputs of knowledge and enhance the efficiency of its leverage makes a significant contribution to knowledge but also to practitioners in HTNVs and the policy makers that support their growth.

Two decades after Cohen and Levinthal's (1989) introduction of the concept of ACAP in the management literature, it is important to further understanding of the complex knowledge processes that occur within the ACAP process and how they are enabled. The culmination of this thesis has led to a temporal conceptualisation of ACAP:

Text Box 8.17

The leverage of knowledge through the ACAP process is cyclical, iterative and cumulative over time involving individual- and firm- level dimensions, with firms building stocks of knowledge at each cycle. The temporality of ACAP is impacted upon by a number of enablers acting synergistically to enhance the efficiency of the ACAP process.

I hope that this thesis will encourage future research that will further explain how firms can better leverage knowledge through the ACAP process.

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Appendix 1

Consent to participate in academic research

and

Principles of ethical research at the University of Glasgow

Consent to Participate in Academic Research

Research Project:

An exploration of absorptive capacity of life science firms in Scotland

Knowledge is a key foundation of competitive advantage in science based high technology ventures. Life science SMEs, competing in a global industry, may not possess all the knowledge they require internally and have to gain it from external sources. A 'company's capacity to absorb is defined by its ability to identify, assimilate and apply for commercial purposes know-how generated outside itself' (Cohen and Levinthal,1990). In internationalising firms, absorptive capacity increases over time, and different types of international experiences enhances this capacity.

This study is concerned with how life science firms develop and expand their absorptive capacity, exploring the routines and processes employed for external knowledge acquisition and assimilation, and the impact on the firm's competitive advantage in an international context. The purpose of this research is academic, within the discipline of business and management. The aim is to advance knowledge on business practice and theory.

The study has received ethical approval as detailed in the university's principles of ethical research (attached). The identities of respondents and firms will not be revealed in published research reports without the express prior permission of the firms concerned. On completion of the study, all respondents are welcome to request a copy of the research report.

Contact Details of Principal Investigator

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Consent to Participate in Academic Research

I: (name) _____

Of (address): _____

_____

_____

Post Code: _____

Telephone: _____

Email: _____

(This information is only needed to obtain consent to the research and will not be used in any results or publications resulting from this research)

The researcher has drawn my attention to the attached Principles of Ethical Research and agree to participate in the under noted research:

Title: An exploration of absorptive capacity of life science firms in Scotland

in which the researcher is named:	Gillian Cay
supervised by:	Prof. Marian V Jones
Supervisor's Telephone:	+44 (0) 141 330 3316/4066

I understand that I have the right to refuse to continue to support the research at any stage, and to require the return and no subsequent use of any data provided, and that special issues of confidentiality or the like listed below will be subject to agreement between myself and the department before any research begins.

Signed: _____

Date: _____

If you require further information about the research please contact the supervisor in the first instance.

If there are any unresolved problems please call the Department and ask for the Chair of the Research Ethics Committee.

Principles of Ethical Research

1. In all forms of research conducted in the Department we will operate with as full a consideration as possible of the consequences of our work for society at large and groups within it.

2. We will handle all confidential information with appropriate levels of discretion and compliance with the law and with due diligence as to the security of that data. We will normally prevent the publication or use of data in any way that could compromise the subject's confidentiality or identity.

3. Any material being prepared for publication both inside and outside of examination purposes will be produced in such a way as to reduce the possibility of breaches of confidentiality and / or identification. If necessary, this process will be subject to a written statement as to agreed process between any sponsors of research, research subjects and the Department.

4. We will try to avoid overburdening subjects, causing them inconvenience and intruding into their private and personal domains.

5. Subjects will be informed as to the purpose and nature of any inquiry in which they are being asked to participate.

6. We will avoid misleading subjects or withholding material facts about the research of which they should be aware.

7. Where the research methodology allows for it, a research subject will be expected to be provided with a copy of these Statements of Principles along with a consent form which will also indicate a subject's right of referral and appeal to a higher authority in the Department and through Faculty to the University Ethics Committee.

8. Where the research methodology suggests that a different kind of consent is the only one possible this will be made clear in the ethical approval form but subjects will be referred to departmental web pages or made aware of these principles by the researcher in order to understand the issues as at paragraph 7 above.

9. All staff, researchers and their supervisors are required, before the project begins, to submit to the chair of the departmental ethics committee, either a short-form or a long form ethical approval form. Only on formal approval by the ethics committee will the project be permitted to begin.

10. In the situations listed in the following subsections, staff, researchers and their supervisors must produce a justified case using a standard Application Form for Ethical Approval.

a. When the research methods employed might be regarded by the lay public to have delicate or controversial elements or when the research might be considered to give rise to adverse publicity for the University.

b. When the research involves the use of individual medical records

c. Where there might be difficulties in obtaining the subject's informed consent. This to include but not be limited to the following examples: with vulnerable people, including children; and those with learning difficulties; when proposing to use covert observation; or when employing a methodology in which the practicalities of obtaining signed consent forms are infeasible.

Only if and when the Departmental or subsequently the Faculty Ethics Committee has approved the research can it commence.

11. All members of staff and all student at all levels are required to read and agree to comply with these statements and to operate them in the full spirit in which they are written. Failure to comply with these statements will be regarded as a disciplinary offence.

12. All researchers and all supervisory staff at all levels must sign an agreement on an annual basis, indicating their acceptance of these Principles.

Appendix 2

Research Instrument Phase 1

Time:	**Company Name:**
Date:	**Address:**
Interviewer 1:	**Telephone:**
Interviewer 2:	**e-mail:**

An exploration of absorptive capacity of life science firms in Scotland

Gillian Cay, University of Glasgow
Professor Marian Jones, University of Glasgow

Instructions to Interviewers

Fill in one booklet per firm (or per interviewee).
The interview should follow the format of open *questions, answered in the respondent's own words, followed by* closed, *checklist questions.*

1. Write the answers to the open questions as told by the respondent, use as much space as necessary.
2. Follow each section of open questions immediately with the corresponding closed questions. in order to verify the respondents story.
3. Ask the closed questions precisely and enter the answers in the spaces provided
4. Once the form is completed, ask the respondent to elaborate on any issues that have emerged during the interview that they think are of particular importance to the future development of their firm

Section A. Open Questions: The Firm's current position

Q. Please tell us about this firm. In your own words please describe your firm, the business it does, the nature of its products, its role within the industry and its competitiveness in domestic and any foreign markets?

Prompts (for guidance)	Please allow the respondent to answer in their own way, and record their responses in their own words
• Business, products and manufacturing or production processes. • Firms' role in its industry (identify the industry). • Suppliers, buyers, new entrants, substitute products, concentration, your position on the industry value chain • Customers/ domestic market, who, where? • Competitive position, market share, unique niche, etc. source of competitive advantage in domestic market. • Describe your firms overseas markets, where are they, how many are they, what do you sell there, what is your source of competitive advantage there?	

Continue on reverse if necessary

Section A. Closed Questions: The Firm's current position *(Please ask questions and record answers precisely in this section)*

A1. Business and Products

1.1 Would you classify your firm primarily as: **1.** a manufacturing firm _____ **2.** a firm producing services _____ **3.** an R&D laboratory_____ or **4.** other, please describe_____? (tick one)

1.2 What percentage of your firm's annual income comes from: 1. Sale of hardware products_____ %, 2. Sale of software products_____ %, 3. Sale of services_____ %, 4. Research grants_____ %, 5. Other _____% (check total = 100%)

1.3 What proportion of your firm's annual income comes from: 1. Business activities/ sources in the UK _____%, 2. Business activities / sources overseas _____ % ? (check total = 100%)

1.4 What is your major product? _____ ?

1.5 Is your major product sold to: 1. consumer markets _____ , 2. organisational markets _____ 3. both _____ ?

1.6 Would you describe your product as: (tick all that apply)

- Having a narrow range of applications within one or a few industries / markets_____,
- Having a wide range of industry applications across a number of industries / markets_____
- Specific to a target group of customers with particular needs_____
- A niche product with local applicability (UK only)_____
- A niche product with global applicability (foreign markets) _____
- General to a wide range of industries / markets in UK and abroad _____

1.7 Would you describe your major product as: (tick one only)

- Innovative, leading edge technology _____
- An incremental innovation of relatively new technology_____
- Other, please describe

  _____

  _____

1.8 Do you have a portfolio of products? 1. Yes _____, 2. No _____? (tick one)
1.9 Could any of your products be described as a Cash Cow? 1. Yes ____ 2. No ____ 3. Might be in the future _____ ?

A2. Industry Structure

2.1 Approximately how many direct competitors do you have in the UK _____ ?

2.2 Are your main competitors large firms _____, or small firms _____ ?

2.3 If you have few competitors, can you identify them by name? _____?

2.4 If you have few competitors are these firms UK owned _____, foreign owned _____, both _____ ?

2.5 How unique is your product or service _____ ?

2.6 How important is your product e.g. could customers use something else in its place _____? What _____ ?

2.7 Is your product easily imitated by another company? 1.Yes _____2. No _____ (tick one)

2.8 Could you do this again? Is it replicable? Yes_____ No _____ (tick one)

A3. Competitive Advantage

3.1 Please describe the source of your firm's competitive advantage in the UK?
_____
_____

3.2 Please describe the source of your firm's competitive advantage in its overseas markets if any?
_____
_____

3.3 How sustainable is your competitive advantage?
_____

Section B. Open Questions: The Firm's Foundation Process

Q. In your own words, please describe how your firm was founded, who was involved, how it was supported, why it was founded and the aspirations, aims and objectives of the founding members.

Prompts (for guidance)	Please allow the respondent to answer in their own way, and record their responses in their own words
• Was there a particular reason for its foundation eg to exploit a new technology or innovation, or other? • Is there any pre-foundation history that influenced the establishment of this firm eg spin-out or spin-off, MBO etc.? Reasons? Opportunities or threats? • Who were the founders, describe, them, what role did they play in founding, what role do they play now? • What international connections did the firm, or its founders have at foundation? What role/contribution have these made to the growth of the firm (in general internationally). • How was the firm resourced at foundation (financial, physical resources, human resources). Where did the resources come from, how did the firm go about getting them?	

Continue on reverse in necessary

Section B. Closed Questions: The Firm's Foundation Process

(Please ask questions and record answers precisely in this section)

B1. In what year was the firm founded? _____

B.2 a). Was the firm founded specifically to develop a scientific/technological innovation? Yes_____(goto 2.1)
b). Since founding, has your firm developed a scientific / technological innovation ? Yes_____(goto 2.1)
(If no to both 2a and 2b, go to 3)

2.1 Please describe that innovation

_____
_____
_____

2.2 What was the source of the firm's **first** scientific/ technological innovation?

	Yes/No	**Source Country**
• In-house development	_____	_____
• University	_____	_____
• Other firm	_____	_____
• Previous employer	_____	_____
• Acquisition of patent rights from third party	_____	_____
• Other_____		

2.3 Does the firm have intellectual property rights for that innovation here, and/or abroad? *(note all countries and sequence in which IPRs were sought).*

_____
_____

2.4 Does the firm have FDA approval for the US Market? Yes _____ Date _____ No _____ Pending_____

B.3 Why was the firm founded?

_____
_____

B.4 How was the firm financed? *(tick all that apply)*

- Research Grant _____
- Enterprise / start-up funding from Government _____
- Bank loan _____
- Founder's personal sources _____
- Other _____

B.5 Was the firm founded as an independent new firm with no corporate history? Yes_____(go to 7), No _____ (go to 6)

B.6 Was the firm founded as: *(tick one only)*

a. A spin-off from another firm _____
b. A spin-off from a university _____
c. Merger/takeover _____
d. Management worker buy-out _____
e. Other _____

B.7 How many founders were there? _____.

B.8 What personal, social or business contacts and networks with individuals or organisations overseas, did the founding team have at start-up?

_____
_____

B.9 To what extent have those links and networks contributed to the development and growth of the firm?

_____
_____

B.10 The table below relates to the human and social capital of the firm at founding. Please record relevant details on each of the founders.

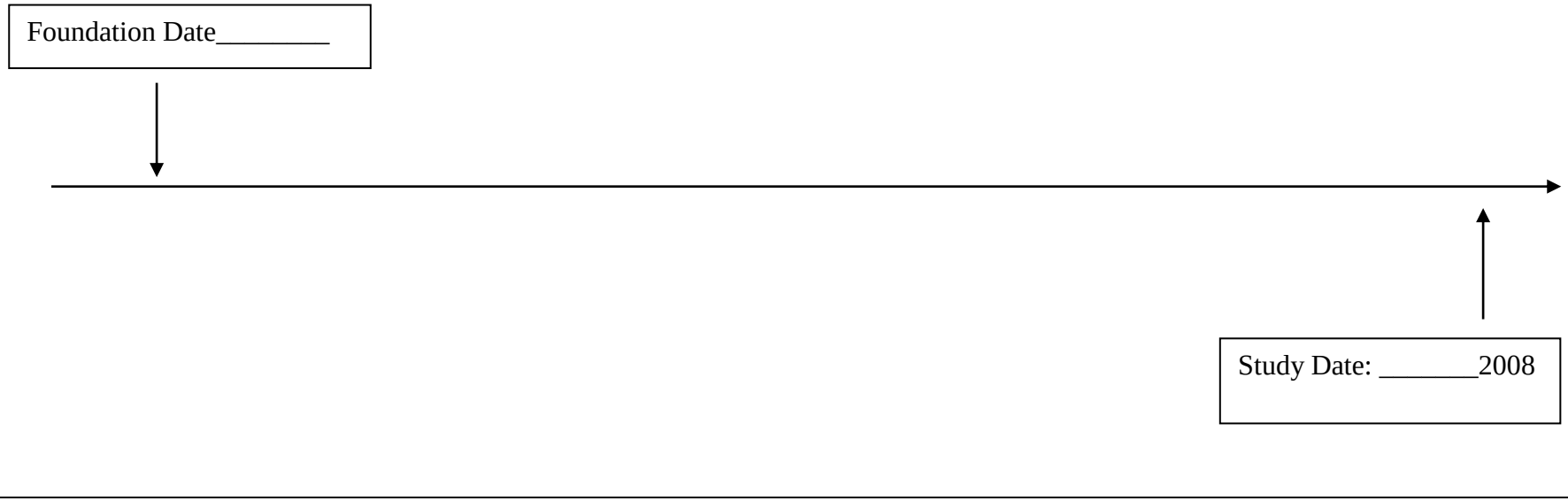
	Founder 1	**Founder 2**	**Founder 3**	**Founder 4**	**Founder 5**
Age					
Gender					
Nationality					
Current role/position?					
Previous entrepreneur? Yes/No					
Family history of entrepreneurship Yes/No					
Highest Level of education, e.g School Cert, College degree/diploma (CD), University 1st Degree (UD), Advanced degree (AD), Doctoral degree (Dr), Professional bodies,					
Overseas education? Where ? Country (ies)					
Overseas working experience Where? Country (ies) SME/MNE? Role Position?					
Working experience in a Domestic internationalising firm?					
Foreign language ability? Languages? Spoken/written/fluent?					

Section C. Open Questions: Critical Events and Milestones (Timeline)

Q. Please tell us about events in the history of the firm, that you see as major milestones, or critical incidents in the development of the firm, or things that happened, internally or externally, that triggered change in the firm's development process? Within this, please tell us about international events from first international links and contacts, to its first international contracts and investments to its current situation as regards involvement in international business.

Enter the foundation date of the firm at the left of the time-line.

1. Record the nature of each event recounted, as the respondent describes it. If internationalisation event, note countries
2. Write the date on the approximate place on the time-line
3. Write the story surrounding the event (continue over for space)



Continue on reverse if necessary

Section C. Open Questions: Prompts Relating to Events on the Firm's Timeline

Q. Please allow the respondent to discuss each event as fully as possible. The prompts relate to each relevant event

Prompts (for guidance)	Please allow the respondent to answer in their own way, and record their responses in their own words
• What triggered this event? • What were the implications for the future growth and development of the firm? • What were the implications for the functional areas of the firm: R&D, manufacture, marketing, distribution, new product development, commercialisation, funding etc. • What implications did the event have for internationalisation or international aspects of the firm's business? • What new processes, or strategies were triggered? • What aspects of the firm's business were dropped? • What were the immediate effects on profitability, financing, sales, revenues etc. • In retrospect, what were the long-term effects?	

Continue on reverse if necessary

Section C. Open Questions: Prompts relating to internationalisation events on the firm's timeline

Q. Please allow the respondent to discuss each event as fully as possible. The prompts relate to each relevant event

Prompts (for guidance)	Please allow the respondent to answer in their own way, and record their responses in their own words
• How did your firm's involvement in international business evolve? • What were the nature of the cross-border arrangements you had? Export, import Licensing in or out of technology, source of technological knowledge, raw materials etc. • What was the purpose of them? Increase knowledge, expand sales, exploit opportunities, avoid unfavourable conditions in home country? • Were there any investments involved (FDI), investment in technology etc.? • What were the implications of your international involvement for the functional areas of the firm: R&D, manufacture, marketing, distribution, new product development, commercialisation, funding etc. • How important is your international activity to firm growth and development in general? • What did the firm learn from its overseas involvement in relation to overseas markets, new product development, marketing techniques and processes, technological techniques and processes, R&D, technology transfer and the protection of intellectual property	

Continue on reverse if necessary

Section D: Types of external knowledge - Open Questions

Q Looking at a critical event for your firm, please tell us how you acquired the external knowledge/information that you consulted in advance of that activity/event or required to conduct/implement that activity.

Prompts (for guidance)	Please allow the respondent to answer in their own way, and record their responses in their own words
• How did you know this event/activity was the right thing for your organisation to progress/pursue? • What knowledge/ information was important to enable you/your management team to make that decision? • Where did you source it from? How did you source it? *Are certain types of knowledge more important that others?* • Who was responsible for acquiring that knowledge? • Who did you consult? • When did you acquire that knowledge? *in advance – knew it would be important* *during –once they realised it was required* *learned it as part of the process* • What investment have you made to be able to access that knowledge? • • Is the knowledge you acquired for this international activity different to the knowledge that was important for your competitive advantage in your other business activities? *If so, why?* *How has it impacted on your business?*	*Type of knowledge* *Source*

Continue on reverse if necessary

Prompts relating to the types of knowledge acquired and sources – use if relevant to critical events being discussed

Knowledge from human capital Did you need to supplement your staff at this event? • What positions/level your recruit and why? • Where did you recruit them from? • What external knowledge did they bring? **Knowledge from external collaborations** Did this event involve a collaboration? • What knowledge did the partner bring? *explicit or tacit knowledge?* • How did you evaluate that knowledge in advance of the collaboration? • How did you establish a fit with your organisation? • How did you know how to value your contribution to the collaboration? • Is your access to the Scottish knowledge base important to your international collaborators? **Experiential knowledge** Did previous internationalisation experience help you in this event*?* • How? What did you learn? What benefit did it give you? • What did you do differently as a result of this knowledge? • If you didn't have previous experience, did you get advice?	

Continue on reverse if necessary

Prompts relating to the types of knowledge acquired and sources – use if relevant to critical events being discussed

Knowledge from relationships What previous relationships/networks have influenced this event? • Have you been able to capitalise on the existing connections of your network? What? • Is building networks important for your company? What networks does your company have? • Is being located within the Scottish life science community helpful to finding the external knowledge you need? *If so what?* • Does access to Scottish academic community/NHS clinicians give you a competitive advantage? *If so what?* • Is your access to the Scottish knowledge base important to your international collaborators? *If so what? Why? Industry hot spot?* • Are local Scottish networking groups useful? *Which ones?*	

Continue on reverse if necessary

Section D: General Knowledge acquisition in your firm - Closed questions *(record precise answers on this sheet)*

Q. Looking at knowledge acquisition routines in general in your firm….

H1 Who is responsible for the decision to acquire knowledge? (Roles/Teams) _____

H2.1 Does the company have clear policies on what external knowledge/technology it is seeking? Yes/No
H2.2 How is that articulated?_____

H.3 Is there any individual(s) whose specific role it is to gather external knowledge? Yes/No *If so who:*

Role/Position	Background/training	Type of knowledge
Individual 1 _____	_____	_____
Individual 2 _____	_____	_____
Individual 3 _____	_____	_____

H4 How do these individuals know what to look for? What is missing? What problems need solving?
Trigger : _____

H5 How do these individuals know what will fit with existing competencies?
_____

H6 What sources of external information do you consult? *Tick all mentioned by*

Market research reports	*Trade press*	*Professional advisers (lawyers/accountants)*
Scientific journals	*Patents*	*SE account manager*
Industry conferences	*Academic scientific conferences*	*Consultants (industry/internationalisation)*
Personal industry contacts	*Personal academic contacts*	*LSBAS advisor*
Customers	*Trade press*	*Mentor*
Competitors	*Legislation/QA standards*	*Internet*
Suppliers	*Trade associations*	
Collaborators	*other (list)*_____	

H7 Do you have listening posts in other parts of the industry/other geographies? Yes/No What_____*Trend scout/technology outpost/matchmaker*

Section E: Knowledge internalisation and exploitation - Open questions

Q Please tell us how information is internalised within your firm. What is the key factors to successful exploitation of external knowledge and what if any investment have you made to enable exploitation of knowledge

Prompts (for guidance)	Please allow the respondent to answer in their own way, and record their responses in their own words
• How is new external information introduced to the organisation? *Communication channels?* • Is it a standard format for presenting external information? *Communication channels?* *Face to face meetings* *Reports circulated* *Seminars* *Evaluation panels* • Who decides if external information should be passed on to other staff/departments? Fit? *Company strategy?, management team?* *Gatekeeper- who?, Influencers- who?* • Is there a particular process/routine employed within your company to decide whether a piece of external information is useful to the company? • What processes/routines do you have to enable the company to make use of the information/knowledge in the future? • What is the key factor to successful exploitation of that external knowledge? • Is the individual that acquired the knowledge involved in its exploitation? • What investment have you made to enable exploitation? *Time/Financial/People* • How has this knowledge impacted your company? • How do you deal with the 'Not invented here' syndrome – or is that not an issue ?	

Continue on reverse if necessary

Section F. Open Questions: R&D and Product Portfolio Management

Q. Please describe the role of R&D in your firm, how it is organised its relation to your portfolio of products, and to the development of new products for local and overseas markets.

Prompts (for guidance)	Please allow the respondent to answer in their own way, and record their responses in their own words
• Do you have an in-house R&D department and if so, how much importance is given to it in terms of numbers of employees, annual investment as a percentage of turnover, education & training of R&D staff etc. • When was the R&D department established? • What role does it play? Research for internal purposes, research for other firms under contract? Research for strategic partners? • What international connections, contracts, involvement does your firm have in relation to R&D. • What are the purposes of the international connections, and how does the firm benefit? • What R&D-based international connections has the firm had that have resulted in commercial business ventures?	

Continue on reverse if necessary

Section F. Closed Questions *(Please ask questions and record answers precisely in this section)*

F.1 Strategy and Planning

1.1 Would you describe your firm's development as: (tick one only)

1. Organic (evolutionary process in response to events and triggers) _____
2. Strategic (develops according to our pre-determined plans)_____
3. A combination of 1. and 2. _____

1.2 Does your firm have a formal, written strategic plan? Yes / No.

1.3 If yes, does that plan make explicit reference aims and objectives relating to your firm's involvement or future involvement in international business activity? Yes / No.

1.4 If yes, does that plan contain explicit targets for Research and Development? Yes / No . For 1year, 2 years, 3 years, 4 years, 5years, over 5 years?

1.5 If yes, does that plan make explicit reference to: (Yes/No)

1. Product portfolio planning _____
2. New product development_____,
3. Adaptation of products for foreign markets _____,
4. Entry into new foreign markets_____
5. Withdrawal from any current international business activities _____
6. Cessation of R&D _____

F.2 Firm Performance and Projections

2.1 How would you rate the performance of this firm in its first five years, on a scale of 1-10, with 1 being unsuccessful, 10 being successful?

Unsuccessful 1 2 3 4 5 6 7 8 9 10 Successful

2.1 Was the firm profitable in the each of the first five years?

Year 1 Y/N Year 2 Y/N Year 3 Y/N Year 4 Y/N Year 5 Y/N

2.2 What percentage of the firm's revenue was derived from overseas in each of the first five years?

Year 1 _____% Year 2 _____% Year 3 _____% Year 4 _____% Year 5 _____%

2.3 What is your firm's current percentage of profits is derived from foreign operations? _____% of total profits?

2.4 What is your firm's current percentage of sales is derived from foreign operations? _____% of total sales?

2.5 Would you mind telling us the approximate total sales of your firm in the last financial year £_____ ?

2.6 Would you mind telling us the profitability of your firm in the last financial year as a percentage of total sales_____ %

2.7 How many staff (FTEs), including working directors does your firm currently employ_____

Appendix 3

Glossary of Terms

Glossary of Terms

ACAP	Absorptive capacity
Biotech	Biotechnology (companies/industry)
CRO	Contract Research Organization
DNA	Deoxyribonucleic acid
GenBank	European gene sequence database available to anyone on the Internet. The sister organization to the National Center for Biotechnology Information in the U.S.
GLP	Good Laboratory Practice
GMP	Good Manufacturing Practice
HTNV	High technology new venture
IE	International Entrepreneurship
INV	International new venture
IPO	Initial Public Offering (sale of stock to the public)
IPT	Internationalisation Process Theory
ISO	International Organization for Standardization (the world's largest developer and publisher of international product standards)
FDA	Food and Drug Administration (the regulatory authority in the USA)
LSBAS	Life Sciences Business Advisory Service
FTE	Full time equivalent (in relation to employment)
KBV	Knowledge-Based View (of strategic Management)
MHRA	Medicines and Healthcare products Regulatory Agency (the regulatory authority in the UK)
Pharma	Pharmaceutical (companies/industry)
RBV	Resource-Based View (of Strategic Management)
SMEs	Small and medium enterprises
TMT	Top Management Team
SDI	Scottish Development International
SE	Scottish Enterprise
SMART	UK Government Department of Trade & Industry SMART (Small firms Merit Award for Research and Technology) awards.
VC	Venture Capital (ist)

Appendix 4

Matrix analysis relating to the use of social capital by HTNVs to enable the leverage of knowledge to resolve growth challenges

These tables are discussed in section 7.9 and summarised in table 7.15

Table A-4 (a) New product development and links/social capital as an enabler to the leverage of external knowledge

Growth challenges (type of innovation)	**Types of social capital**	**How**	**D/ I**	**Pre/post**	**What knowledge**	**Knowledge acquired**	**E/ T**	**Capability developed**	**Link transformed**	**Growth /outcome**
New product /service development (product innovation) (A,B,D.E,F,G,I)	Academic links (A, B, E, G)	Regular contact with key links in local unis (A,B, E, D)and international research groups (A) Relationship cemented over many years (A, B, E, G) Conferences (A) Maintain links through Scientific advisory Board (G)	D &I I	Pre & Post	Developments in specialist technology field (A, E, G) Contacts (A, B) Location of experts (A, B, E, G) Locations of and access to specialist facilities (A, G) Research customer requirements and issues (A, B) Technical support (A,B) Clinical applications of technology (G)	TK (A, B, E, G)	T E E & T T T E & T	Access to technology before the rest of the industry (A) Licenses to use technology (A) Understanding of demand for solutions to research customer problems (A) Develop reputation as a leader (A) Access to facilities and expertise (A, B, G) Assistance with validated assays (B) Potential product portfolio (G)	Licensor of IP (A) Sharing know-how(A) Small volume customers (A) Outsourcing supplier of facilities Location for satellite research laboratory (B) Testing platform for new product (B), assays (G) Building bank of evidence to support marketing claims (G) Scientific advisory board members (G)	Source of NPD ideas (A) Sales growth (A) Sales to research customers (A) Product development projects within facilities leads to new products (A) New services (B)
	Existing business links (A,B,D,E, G)	Meet potential customers and competitors at specialist conferences (A,B,D, G) Build relationships with key players (A) Building relationships from previous employment(D,E)	I	Post (A,D)	Competitor offerings (A, G, H) Gaps in the market (A, G) Unmet needs (A, G) Solutions required (A,D) Industry trends and developments(A,D, G) Further contacts in pharma (D) Current research and requirements(D) Safety testing requirements (E) What is valued in safety testing (E)	MK (A,B,D,E, G) RegK (E)	E & T T T T T T	Understanding of the industry dynamics (A,D,E) Influence higher up the value chain even though sales will come from downstream (A) Anticipating future industry demand,Positioning new product/service offerings(A, D,E, G) Being seen as a source of solutions/ and expert (D, G) Develop trust with customers (D) Creating added value (E)	Customers (A,D,E)	Sales growth (A,D,E)

Cases A-I = high technology new ventures in this study, Types of knowledge : Explicit/Tacit (Nonaka, 1994), Geographical location of link: D= domestic, I= International
Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=managerial knowledge, RegK=regulatory knowledge, IK= internationalisation knowledge
Timing of link development: Pre = pre-foundation, Post = post-foundation

Table A-4 (a) New product development and social capital as an enabler to the leverage of external knowledge (continued)

Growth challenges	Link	How	D/ I	Pre/ post	What knowledge	Knowledge acquired	E/ T	Capability developed	Link transformed	Growth /outcome
New product /service development (innovation) (A,B,D.E,F,G,I)	New business links	Previous employment of new sales staff (B) At specialist conferences (A,B,G) Proactive building of links (G, I)	D &I	Post (A, B)	Customer contacts (B) Customer requirements (B) Customer research directions (B) Change in pharma capital equipment buying behaviour (B) Industry dynamics and trends (A, B, G, I) Potential distributors of diagnostic test (G)	MK (B, I)	T	Interpretation of customer requirements led to the defining of service offering and assisted positioning of services (B) Evaluation of new service options (B) Creation of R&D department to develop new validated assays (B) Potential routes to market (G, I)	Some links have become customers (B) Testing platform for new product (B)	Sales growth New assay portfolio developed
	Special interest groups(A, E, G,D)	Nucleic Acid network (A) Regulatory network(E) Animal health networks (G) CRO conferences (D)	I I	Post Pre	Regulatory issues in the sector (E) Market dynamics (A,D,G) Potential distributors of diagnostic test (G) European diagnostics firm contacts (G)	RegK (E) MK (A,D,G, H)	E & T	New service opportunities (E) Potential routes to market (G)	Seen as a leader in the field (A,G)	Sales growth (A,E)
	Local networking group	Face to face meetings	D	Post	Local firm that can assist with manufacturing of assay	TK, MK	T	Manufacturing partner identified	-	-

Cases A-I = high technology new ventures in this study, Types of knowledge : Explicit/Tacit (Nonaka, 1994), Geographical location of link: D= domestic, I= International
Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=managerial knowledge, RegK=regulatory knowledge, IK= internationalisation knowledge
Timing of link development: Pre = pre-foundation, Post = post-foundation

Table A-4 (b) New market development and social capital as an enabler to the leverage of external knowledge

Growth challenges	Link	How	D/ I	Pre/ post	What knowledge	Knowledge acquired	E/ T	Capability developed	Link transformed	Growth /outcome
New market sector development (A,B,D.E,F,G,I)	Existing business links (A)	Former employment of existing link is central to the network of contacts for new market (A) Customers and potential customers(B)	I	Post	Customer contacts(A, B) Industry dynamics and trends (A, B) Technical requirements required - each project brings additional knowledge about customers' needs (B)	MK (A), RegK (A), TK (A), MngK (A) MK, TK(B)	T	Accurate interpretation of industry trends, customer requirements and entry barriers (A) Development of new services (B) Knowledge bank – SOPs for the future (B)	New Chairman (A) Customers of one service can become customers of multiple services (B)	Credibility in new market – opened doors to players in new market (A) Opportunities for cross selling (B)
	New business links (A,B,G)	At conferences (A, B, C, G) Through existing links (A) Meetings (A, C)	D &I	Post	Customer quality expectations (A, G) Regulatory constraints Customer requirements (A, B) Customer problems and unmet needs (A)	MK (A, G) RegK (A,B)	T	Confidence that firm can service the market (A) Investment in quality standards and manufacturing facilities to meet market demand(A) Gaps in the market (A, B) Service positioning (B) – ability to position skill set to resolve customer unmet needs	New large volume customers (A) Some new customers (B)	Increased sales growth and profitability (A) Sales (B)
	Links with gatekeepers of pharma networks (D)	Gatekeeper for particular services (D)	I	Post	Other contacts within the pharma co. & their requirements (D) Research direction of the pharma co (D)	MK, TK	T	Good reputation and trust developed with this customer (D) Reputation for solving problems (D)	Customers from several of the research groups linked to gatekeeper (D)	Sales growth (D
	Special interest groups	Scientists presenting at conferences(G) Attending conferences (A,B,D,E,F)	I	Post	Customer problems (A) Contacts (G) Clinical applications for technology (G) Industry trends/developments (A,B,D,E,F,G)	MK, TK	T	Seen as a leader in field (G)	Ability to position product offering (G) Customers (A,D)	Sales growth (D)
	Local networking groups	Contact at networking event (D)	D	Post	Contacts (D)	MK	T	-	Customer (D)	Sales
	Investor links	Board members came with investment (F,)	D &I	Post	Distribution contacts and tactics for regulatory hurdles F)	MK RegK	T		New board members	
	Director links (F)	Previous employment in Nursing	D	Pre	Contacts in the Royal College of Nursing	MK	T	Product launch at the Royal College of Nursing Annual Conference (F)	-	-
	Chairman links (G)	Previous employment (G)	I	Post	Contacts in the veterinary market (G)	MK	T	Credibility to the firm (G)		

Cases A-I = high technology new ventures in this study, Types of knowledge : Explicit/Tacit (Nonaka, 1994), Geographical location of link: D= domestic, I= International
Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=managerial knowledge, RegK=regulatory knowledge, IK= internationalisation knowledge
Timing of link development: Pre = pre-foundation, Post = post-foundation

Table 7.15 (c) International market development and links/social capital as an enabler to the leverage of external knowledge

Growth challenges	Link	How	D/ I	Pre/ post	What knowledge	Knowledge acquired	E/ T	Capability developed	Link transformed	Growth /outcome
New International market development (A,B,D,E,F,G,I)	Existing business Links (F)	Previous employment (D,E)	I	Pre	Contacts in multiple overseas markets	MK, RegK, IK	T	Understanding of customer requirements and industry dynamics (D,E)	Customers	Sales Growth (D, E)
	Links with SDI (B)	Attending SDI led missions (B)	I	Post	Contacts in overseas markets(B)	IK (B)	T	Use of SDI services to capitalise on international opportunities	-	International customers
	New business links (D,I)	Conferences (D) Active search for partners (I)	I I	Post Post	Regulatory requirements in US Concerns with xxx supply form the UK (D) Dynamic of industry (I)	RegK, IK, MK MK, RegK	E & T	Sourcing form the US for US clients Amended marketing communications to address concerns of US market (D) Evaluation of exploitation options (I)	Some customers (D) Distributor in the US (I)	Sales growth (D) -
	Director/Investor links (F, I)	From previous employment of directors (F) Through chairman (I)	I I	Pre Post	Distributor contacts within the US and Canada Access to regulatory knowledge for market entry choice (I)	MK, IK (F) MK, RegK (B, I)	T T	Route to market in the US and Canada as soon as regulatory approval is granted US chosen as a first international market (I)	- -	-
	Chairman (A)	Existing links	I	Post	Contacts in international markets	MK, RegK, IK	T	Relationships built with key potential customers	Customers	Sales Growth
	Personal links (F)	Friendship that has been maintained by a director	I	Post	Knowledge of Asian markets	MK	E & T	-	Potential agent for Asian markets	-

Cases A-I = high technology new ventures in this study, Types of knowledge : Explicit/Tacit (Nonaka, 1994), Geographical location of link: D= domestic, I= International
Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=managerial knowledge, RegK=regulatory knowledge, IK= internationalisation knowledge
Timing of link development: Pre = pre-foundation, Post = post-foundation

Table A-4 (d) The development of collaborations and links/social capital as an enabler to the leverage of external knowledge

Growth challenges	Link	How	D/ I	Pre/ post	What knowledge	Knowledge acquired	E/ T	Capability developed	Link transformed	Growth /outcome
Collaborations (D,E)	Academic links (E)	Maintaining relationships (E)	D	Pre	Services provided by complementary organisation (E)	TK	E & T	Opportunity to create a one stop shop for biosafety testing (E)	Collaboration agreement signed(E)	Increased sales for both organisations (E)
	Existing business links(D)	Building relationship (D)	D	Pre	HT license and willing to act as a TB for the firm(D) Customer requirements (D)	MK, TK	T	Partnership agreement has enabled the creation of stock of high value assets that will enable future sales (D) Joint marketing(D)	Partnership agreement (D)	Increased sales (D)

Cases A-I = high technology new ventures in this study, Types of knowledge : Explicit/Tacit (Nonaka, 1994), Geographical location of link: D= domestic, I= International
Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=managerial knowledge, RegK=regulatory knowledge, IK= internationalisation knowledge
Timing of link development: Pre = pre-foundation, Post = post-foundation

Table A-4 (e) Attaining quality standards and social capital as an enabler to the leverage of external knowledge

Growth challenges	**Link**	**How**	**D/ I**	**Pre/ post**	**What knowledge**	**Knowledge acquired**	**E/ T**	**Capability developed**	**Link transformed**	**Growth /outcome**
Attaining quality standard/ regulatory authority accreditation or approval (A,B, E,F, I)	New business links	Potential customers at Conferences (A) Sales director contacts from previous employment (B)	I I	Post Post	Can't work with you unless you have quality standard (A, B). Customers require other quality systems around the basic ISO/GLP standard (A,B)	MK, RegK	T	Understanding of requirements of the market (A) Investment in attaining quality standard (A, B)	Some have become customers (A)	Sales growth (A, B)
	Existing business links (E)	Previous employment (E)	D &I		Customers require quality standards to be in place, also need trust and reliability	MK, RegK	T	Services developed that conform to the standards required, and other aspect of delivering a high quality service (E)	Customers (E)	Sales Growth (E)
	Links of chairman (B, I)		D	Post	Contact that can help with regulatory issues (B,I)	RegK	T		New Board member (I, B)	
	Links of new board member (B,I)	Links from previous employment of board member	I	Post	Understanding of how to conform to regulatory guidelines (I) Regulatory drivers (B)	RegK	T	Enhanced understanding of regulatory submission (I) Enhanced understanding of regulatory authorities (B)Developing a bank of evidence to take to regulators (B)		
	Investor links (F)		D &I	Post	Tactics for regulatory hurdles	RegK	T	Ease the path to regulatory approval (F)		
	Links with policy makers (B)	Strategic development	D	Post	Who can influence the increased availability of human tissue in the UK	RegK	T	Attempting to influence human tissue regulation	-	Too early to say what the outcome will be (B)

Cases A-I = high technology new ventures in this study, Types of knowledge : Explicit/Tacit (Nonaka, 1994), Geographical location of link: D= domestic, I= International
Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=managerial knowledge, RegK=regulatory knowledge, IK= internationalisation knowledge
Timing of link development: Pre = pre-foundation, Post = post-foundation

Table A-4 (f) Raising finance and social capital as an enabler to the leverage of external knowledge

Growth challenges	Link	How	D/ I	Pre/ post	What knowledge	Knowledge acquired	E/ T	Capability developed	Link transformed	Growth /outcome
Raising finance (B,E,F,G,I)	Local network links(E)	Via SE	D	Pre	VC contacts	Mng K	T	Funding secured	Investors (E)	Resources to implement to business plan
	Local business angel network (I)	Via SE	D	Pre	Business Angel contacts (I)	Mng K	T	Funding secured	Investors (I)	Resources to implement to business plan
	Links of the Chairman (E)	Investor network	D	Post	VC and business angel contacts	Mng K	T	Funding secured	Investors (E)	Resources to implement to business plan
	Investor links (E)	Meeting other portfolio companies	D	Post	Common issues for small cos Tactics for raising further finance	Mng K	T	Funding secured	Investors (E)	Resources to implement to business plan
	Existing business contacts (F)	Previous employment	D &I	Pre	Distributor contacts (F)	Mng K, MK	T	Funding secured Routes to market	Investor (F)	Resources to implement to business plan

Cases A-I = high technology new ventures in this study, Types of knowledge : Explicit/Tacit (Nonaka, 1994), Geographical location of link: D= domestic, I= International
Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=managerial knowledge, RegK=regulatory knowledge, IK= internationalisation knowledge
Timing of link development: Pre = pre-foundation, Post = post-foundation

Table A-4 (g) Investment in production facilities and social capital as an enabler to the leverage of external knowledge

Growth challenges	Link	How	D/ I	Pre/ post	What knowledge	Knowledge acquired	E/ T	Capability developed	Link transformed	Growth /outcome
Investment in newproduction facilities/increasing capacity (A,B,E)	New Business Links (A)	Building relationship (A)	I	Post	Volumes of product required and manufacturing standards (A)	MK TK RegK	T	Scale up of production facilities(A)	Customers (A)	Sales (A)
	Existing and new business links(E)	Building & maintaining relationship (E)	I	Pre	Customer requirements (E)	MK, TK, RegK	T	Operations facilities to meet customer requirements (E)	Customers (E)	Sales (E)

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Timing of link development: Pre = pre-foundation, Post = post-foundation

Table A-4 (h) Sourcing key suppliers and social capital as an enabler to the leverage of external knowledge

Growth challenges	Link	How	D/ I	Pre/ post	What knowledge	Knowledge acquired	E/ T	Capability developed	Link transformed	Growth /outcome
Sourcing supplier/outsourcing partners (B,D,F,I)	Academic links (D)	Links with potential Not for profit suppliers (D)	I	Post	Specialist supplier offerings and capabilities Added value expertise with the xxx (D) Funding crisis in supplier creates need for funding stream (D)	TK MK	T	Re-defined service offering Service positioning New service development using this xxxxx Trust developed with suppliers	Multiple supplier /MTA agreements in place(D)	Guaranteed sources enables better business planning and increased sales (D)
	Existing business links (B,F)	Initial links with potential supplier(B) Maintaining links with component manufacturers(F	D	Pre	Very little availability of supply Contract manufacturer contacts and capabilities (F)	TK TK	T	No great help to the firm Understanding that other networks needed to be investigated Understanding of efficient tendering process (F)		
	New business links (B,D, F, I)	Supply network built up over years (B) Contacts of the new supplier network manager (B) Building links with suppliers (B, D) Building links with component manufacturers (F) network contact (F)	D &I I D &I	Post	Capabilities of each organisation (B) Availability and costs of high end consumables (B) Technical expertise (I) Industry knowledge Contract manufacturer contacts and capabilities (F) Clinical trial site options (F)	TK, MK (B, I)	T	Ability to better predict availability of supply (B) Better relationships with suppliers enables faster service and stronger sales growth (B) A source of competitive advantage (B) Better positioning of service offering(D) Better strategic planning (D) Understanding of efficient tendering process (F) Transfer of clinical trial to new clinical Centre (F)	Some agreements signed, others still ad-hoc as required. (B,D) Contracts in place (I) Research agreement in place (F)	More frequent supply of certain consumables means a lower attrition rate in the lab which leads to higher profitability for the firm (B) Sales growth (B,) Cost efficiencies and enhanced profitability (B, D)
	Links with policy makers (B)	Strategic development	D	Post	Who can influence the increased availability xxxxx in the UK	RegK	T	Attempting to influence human tissue regulation	-	Too early to say what the outcome will be (B)

Cases A-I = high technology new ventures in this study, Types of knowledge : Explicit/Tacit (Nonaka, 1994), Geographical location of link: D= domestic, I= International
Types of knowledge: TK=technical knowledge, MK=market knowledge, MngK=managerial knowledge, RegK=regulatory knowledge, IK= internationalisation knowledge
Timing of link development: Pre = pre-foundation, Post = post-foundation